PROCEEDINGS

OF THE

THIRD

SILVICULTURAL CONFERENCE.

Dehra Dun, March 14th—20th, 1929.

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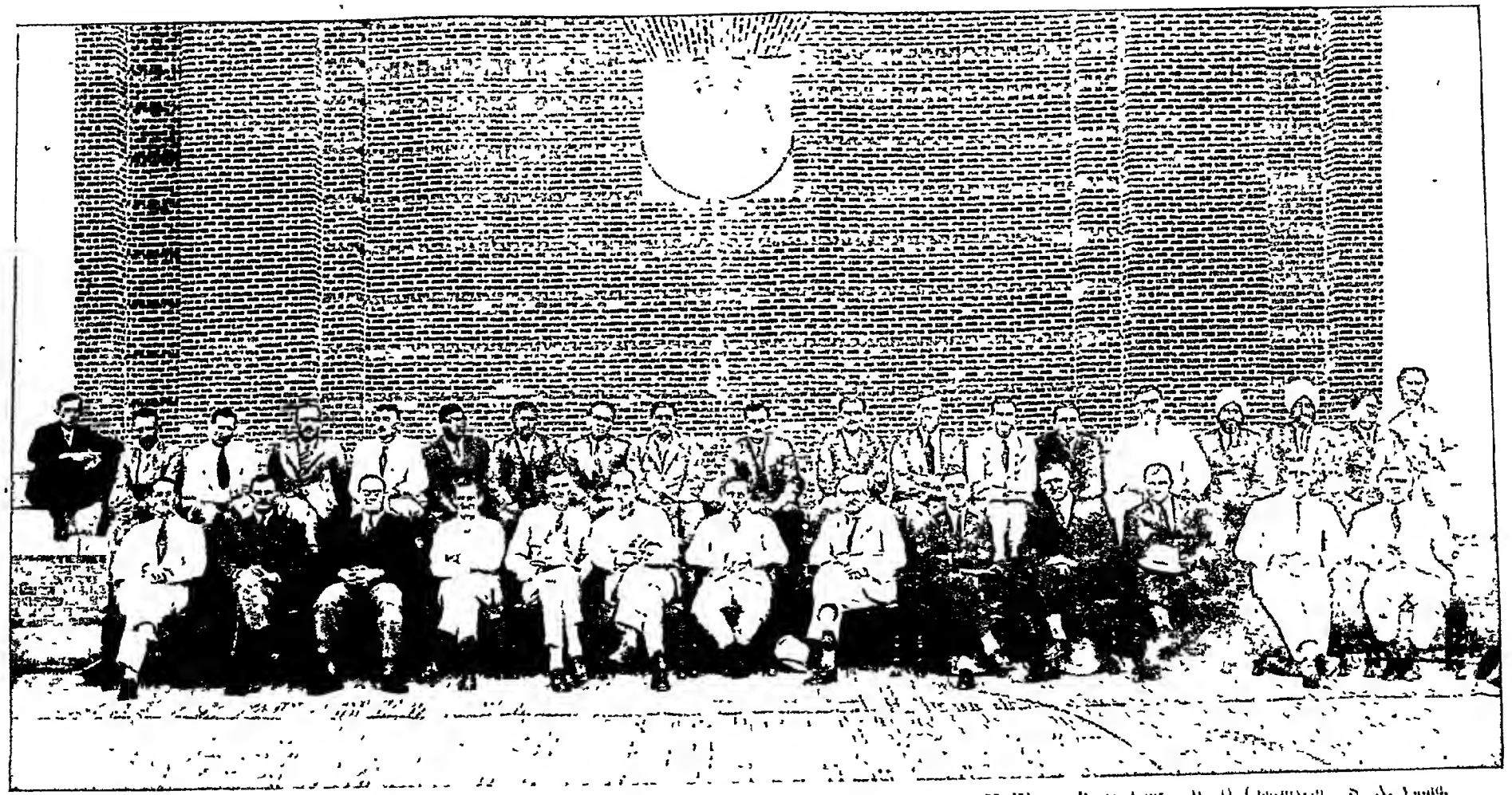

Back row. A. M. C. Littlewood, R. B. Cornwell, G. R. H. Gorley, G. D. Kitchingman, G. S. Shirley, S. N. Khan, B. D. Lant, M. D. Chaturvedi, S. A. Vahid, F. C. Osmaston, E. A. Garland, G. C. Robinson, S. H. Howard, C. E. Simmons, C. K. Homfray, Balwant Singh, Sher Singh, P. N. Suri, I. D. Mahendru.

Front row. F. A. A. Hut, C. J. Rowlotham, C. M. Harlow, A. H. M. Barrington, A. A. F. Minchin, H. L. Newman, C. G. Trevor, H. R. Blanford, E. A. Smythies, H. M. Glover, E. O. Shebbeare, H. G. Champion, C. T. Trigg

Proceedings of the Third Silvicultural Conference, Dehra Dun, March 14th—20th, 1929.

The first conference was held at Dehra Dun, from October 21st to 26th, 1918

The second conference was held from January 10th to 14th, 1922, at Dehra Dun.

The third conference was the first to be held in the new Institute at New Forest, Dehra Dun.

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The following attended in an official capacity:—

Province.	Office.	Name of Officer attending Conference.
Forest Research Institute and College.	President, Forest Research Institute.	Mr. A. Rodger.
,,	Vice-President	Mr. C. G. Trevor.
,,	Silviculturist	Mr. H. G. Champion*.
Forest College	Lecturer	Mr. C. E. Simmons*.
,,	Lecturer	Mr. C. T. Trigg.
Assam	Silviculturist	Mr. C. J. Rowbotham*.
Bengal	Conservator of Forests	Mr. E. O. Shebbeare.
,,	Silviculturist	Mr. C. K. Homfray*.
Bihar and Orissa	Forest Research Officer	Mr. F. C. Osmaston*.
,,	Working Plans Officer	Mr. F. A. A. Hart.
Bombay	Chief Conservator of Forests	Mr. H. L. Newman.
,,	Deputy Conservator of Forests	Mr. E. A. Garland.
Burma	Conservator of Forests	Mr. A. H. M. Barrington.
,,	Conservator of Forests, Working Plans.	Mr. H. R. Blanford*.
,,	Silviculturist	Mr. G. S. Shirley*.
Central Provinces	Superintendent of Working Plans and Research.	Mr. C. M. Harlow.
,,	Silviculturist	Mr. S. A. Vahid*.
Coorg	Chief Forest Officer	Mr. G. C. Robinson.
Madras	Conservator of Forests, Working Plans.	Mr. A. A. F. Minchin.
,,	Forest Research Officer	Mr. A. M. C. Littlewood*.
N. W. F. Province	Deputy Conservator of Forests	Mr. G. R. H. Gotley.
,,	Divisional Forest Officer	Mr. Balwant Singh*.
Punjab	Conservator of Forests, Working Plans and Utilization.	Mr. H. M. Glover*.
,,	Deputy Conservator of Forests	Mr. G. D. Kitchingman.
,,	Officer in Charge, Forest School	Mr. Parmanand Suri*.
United Provinces	Special Hay Officer	Mr. E. A. Smythies.
,,	Deputy Conservator of Forests	Mr. S. H. Howard.
,,	Silviculturist	Mr. M. D. Chaturvedi*.
Kashmir	Assistant Conservator of Forests	Mr. Sher Singh*.

* Members whose names are marked with an asterisk were also present at some or all of the meetings of the Experimental and Statistical Committee on March 14th and 15th.

The following were also present and took part in some of the discussions :—

Province.	Office.	Name of Officer attending Conference.
Forest College . .	Instructor	Mr. R. B. Cornwell.
,, . .	Instructor	Mr. H. P. W. Davis.,
,, . .	Assistant Instructor . . .	Mr. S. N. Khan.
Forest Research Institute.	Assistant to Silviculturist . .	Mr. I. D. Mahendru.
,,	Assistant to Silviculturist . .	Mr. B. D. Pant.
United Provinces .	Assistant to Silviculturist . .	Mr. Sohan Singh Negi.
Punjab . . .	Extra-Assistant Conservator of Forests.	Mr. Hari Singh.

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PROGRAMME.

Thursday, March 14th—	
2 P.M. . . .	Committee of Silviculturists and Provincial Research Officers and others specially interested meets to discuss Item 1 of the Agenda at the office of Central Silviculturist.
Friday, March 15th—	
10 A.M. . . .	Committee meets to discuss Items 2, 3 and 6.
2 P.M. . . .	,, ,, ,, Item 11.
Saturday, March 16th—	
10 A.M. . . .	(*a*) Opening address by the Inspector General of Forests (p. 3). (*b*) Appointment of officers (p. 4). (*c*) Procedure of the conference (p. 4). (*d*) Announcements (p. 5). (*e*) Appointment of committees (p. 5) for Items 5, 14, 15 and 19. Item 1.
2 P.M. . . .	Inspection of Economic Workshops, starting from the Sawmills (p. 7).
Sunday, March 17th—	
10-30 A.M. . .	Excursion in *sal* forests of Dehra Dun Division, meeting at Asarori at 10-30 A.M. About 35 miles drive, returning about 4 P.M. (p. 7).
Monday, March 18th—	
10 A.M. . . .	Items 2, 3, 4, 6, 7 and 8.
2 P.M. . . .	Items 9, 10 and 14.
Tuesday, March 19th—	
10 A.M. . . .	Items 11, 12, 13, 15 and 16.
2 P.M. . . .	Items 17, 18 and 20.
Wednesday, March 20th—	
10 A.M. . . .	Items 21 and 22. Reports of Committees on Items 5, 14, 15 and 19.
2 P.M. . . .	Resolutions.

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OPENING ADDRESS.

By

MR. A. RODGER, O.B.E., *Inspector General of Forests and President, Forest Research Institute and College.*

Gentlemen.—It gives me much pleasure to welcome to the new Forest Research Institute such a large and representative gathering of Indian forest officers. It is all the more pleasing to the staff of the Forest Research Institute and College to welcome you here because this is the first Conference to meet at the new Institute since it was completed. I am sure you will agree that the Government of India have equipped us with buildings capable of dealing with Forest Research for India on a scale that none of us would have dreamt of a few years ago.

I see that we have here 24 representatives from all the provinces as well as from an important Indian State, a considerably larger number than were here 7 years ago, when we held the last Silvicultural Conference under the Chairmanship of Mr. Perree.

In looking through the Report of the Proceedings of the Silvicultural Conference of 1922, I have been struck by the fact that the practical outcome of the Resolutions has not been all that we could wish. For instance Resolution 2 decided that Conferences be held every three years in Dehra Dun and the other two years in provinces. This has certainly not come to pass. Again we have not yet succeeded in getting an Assistant Silviculturist though I have hopes that we may do so within a few weeks. I believe, however, that our progress will be greater after the completion of the present sitting. There have been many circumstances which have formed obstacles to progress, but it is unnecessary to enter into too many particulars about past history.

The Agenda for the present Conference appear to me to be extremely comprehensive and I am particularly interested in a number of the items.

The relation of Central and Provincial Silviculturists is a subject which appeals to us all, particularly at the present moment when a Committee appointed by the Government of India is sitting here to advise, among other matters, on the best methods of ensuring co-ordination between Dehra Dun and the provinces.

We are tied up sometimes by the extraordinary rules made by Government departments. For instance who could imagine that any province would ask the Inspector General of Forests to pay Rs. 81 for a single copy of an ordinary working plan? This is an absolute fact, and I would ask for your co-operation in ensuring that all forest officers who are interested, should obtain working plans from their own and from other provinces at a nominal figure. Nothing could be worse for us than to be ignorant of what our own people are doing in other provinces in working plans and silviculture, and I may say that it is equally undesirable that officers in provinces should be ignorant of what we are doing at Dehra Dun. I have found when visiting Divisional Forest Officers and others, that some of them were not aware that we had recently published notes on subjects in which they were specially interested. The Editor of the " Indian Forester " publishes regularly a list of all our publications and I would ask all research officers in the provinces to make a point of obtaining these regularly.

Two subjects which appeal to me greatly are Nos. 8 and 9, pure teak plantations, and the regeneration of evergreen forests. I am partly responsible for the latter subject as I have kept it before our Silviculturist for some time. I look forward to the Conference giving us much valuable advice on these matters.

Research on thinning, record and control of silvicultural work done in divisions, and standardisation of stock mapping methods and symbols, are all subjects on which I think the Conference can come to most important decisions.

That is what the provinces and the Forest Research Institute want, and I promise you that I shall do my best to ensure that effect is given to the

Resolutions you pass with the minimum of delay and alteration by Government departments.

It may not be possible for definite resolutions to be passed in all cases, but we shall have the advantage of much valuable discussion among experts.

I am sure that the Conference will be able to leave us decisive, brief, and clearly drafted instructions on all the points raised in the Agenda.

The Conference can help us very much by giving definite expression to its views in the matter of the appointment and training of provincial silviculturists. At present provincial silviculturists are often appointed direct from divisional work without any, or with little, practical experience of research work, and I feel sure you will agree with me that this is not advisable. A small point I would like to draw your attention to is the use, or misuse, of vernacular terms in reports. The word *Taungya* is now understood almost everywhere in India, but there are many other vernacular words one finds constantly in reports, and they are very often words which are understood only in one province or even in one part of a province. I would ask you to do your best to see that all such terms are avoided.

Mr. Trevor and Mr Champion have, I consider, carried out the preparation, printing, and general organisation for the Conference in the most efficient manner, and I think our very hearty thanks are due to them for the splendid work they have done.

It has been the custom in the past for the Board of Forestry to consider the proceedings of the Silvicultural and Economic Conferences and this will probably be done by the next Board which meets. You may be aware that the Board should have met in 1928, but was unable to do so because of the Empire Forestry Conference in Australia. It might meet during next rains, but we feel here that we have had enough Conferences and Committees for one year. More important even than that, is the fact that the next Board of Forestry should meet as soon as possible after the Simon Commission has issued its report, as that report may bring very great changes to our service.

If Forests are transferred in all provinces there is a great danger that we shall begin to lose touch with one another. Nine services cannot be the same as one service; and if recruitment, pay and conditions of service vary considerably, it would seem that our interests will become very divergent. This I consider will be the greatest misfortune that could ever befall the Indian Forest Service, and I appeal to you, as fully representing the most scientific side of Indian Forestry, to do your best to prevent it. It is not only that the science of forestry will suffer from the lack of free interchange of ideas, but that the *esprit de corps* of all the forest departments will deteriorate. I believe that the members of this Conference can, at the very outset, do a great deal to help by meeting officers from other provinces as often as possible, by visits, by correspondence and by interchange of notes, and by making a point of taking in all each other's publications, and of supporting the "Indian Forester", for the support of which, now in its 52nd year, I make a special appeal to the members of this Conference.

I wish the Conference every success in its deliberations and propose that Mr. Trevor be elected Chairman and Mr. Champion Secretary.

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APPOINTMENT OF OFFICERS.

The following were appointed as officers for the Conference :—

Mr. C. G. Trevor, Vice-President, Forest Research Institute and College . . . . . Chairman.

Mr. H. G. Champion, Silviculturist, Forest Research Institute . . . . . Secretary.

Mr. C. T. Trigg, Lecturer, Forest Research Institute and College . . . . . Assistant Secretary.

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PROCEDURE.

The Chairman made the following proposals, which were accepted.

The procedure which I am going to propose is more or less founded on the procedure that we found very successful in Australia. The first thing is that all speeches should be made to the Chair, and that officers should kindly refrain from entering into conversation while other members are speaking. I propose to give writers of papers some preference in debate. As regards votes, you will remember that at the last Silvicultural Conference, there was a good deal of discussion about voting, and it was arranged that each province should have one vote per territorial circle. I do not think that there is any necessity for it. I think that if we vote by a show of hands and every member of the Conference has one vote, it is all that is necessary. If any item is so controversial that a division is necessary, I hardly think a resolution on such subject is worth passing.

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ANNOUNCEMENTS.

The Chairman announced:—"The Silviculturist has an exhibit of different types of fencing in his Experimental Garden, and those interested in the matter (it is now becoming a very important one) might visit them and favour us with their ideas. The Silviculturist also has a collection of varieties of loose leaf binders on which he would be glad to have the opinions of those who have practical experience of them."

Announcements were also made concerning the arrangements which had been made for lunch at the Institute, and for the excursion in the forests of the Dun on Sunday, March 17th.

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APPOINTMENT OF COMMITTEES.

Item 5.—Revision of the Glossary of Technical Terms.

The Chairman made the following remarks:—

"I should like to say that a considerable amount of time has already been taken in revising this glossary, and that the chief terms used in forest management were considered by a Committee at the Australian Conference and were ultimately passed. The Conference agreed that these terms should be used all over the Empire. These terms have now been incorporated in the revised glossary which I have before me, and we cannot depart from them as we have already agreed to accept them. Apart from that, many officers have suggested that the glossary should be referred to a Committee of the present Conference. I have here the latest edition of the draft glossary containing most of the corrections and alterations which members of the Conference have proposed, and I now think that they should go before a Committee. It has been suggested that Messrs. Blanford, Smythies, Minchin, Kitchingman and myself might sit on this Committee, and report to the Conference at a later date."

The Conference finally appointed the five gentlemen named as a committee on item 5.

Item 14.—Methods of Research on Thinning.

Mr. Homfray proposed that this item should be referred to a Committee to meet and thrash out certain moot points, and put up definite proposals to the Conference as a whole.

Messrs. Champion, Chaturvedi, Glover, Harlow, Homfray, Osmaston, and Shirley were suggested to sit on the Committee.

Mr. Howard suggested that it is not necessary to have everybody represented on the Committee and that such committees must be small to be workable.

The Chairman remarked that in his experience, it is generally the Chairman of the Committee who does all the work, and mentioned that any committee could co-opt any member of the Conference to give evidence or to state his views before the Committee.

Messrs. Champion, Glover, Homfray and Shirley were appointed as Committee on Item 14.

Item 15.—Standardisation of Stockmapping Methods and Symbols.

This item was to have been dealt with by Mr. Walker (Bombay) but he unfortunately did not attend the Conference after all, and did not hand over any notes on the item.

The Chairman asked Mr. Blanford if he would deal with it and suggest that the matter be referred to the Committee if he thought necessary.

Mr. Blanford suggested Mr. Osmaston, Mr. Trevor and himself for the Committee.

The Chairman proposed Mr. Sher Singh as representing conifers from Kashmir State, and also proposed Mr. Harlow's name in place of his own. The Committee was appointed accordingly.

Resolutions Committee.

The Chairman pointed out that any resolutions proposed should ordinarily be drafted by some gentlemen particularly concerned, and handed to the Committee to be appointed to scrutinise the drafts and put them before the Conference at the last session. Mr. Newman was asked to preside over the Resolutions Committee and Messrs. Shebbeare and Howard were also asked to serve on it. They consented to do this and were appointed.

Experimental and Statistical Committee.

The Secretary pointed out at the first full session that this Committee, which had been sitting for the previous two days to deal with the more or less routine matters of sample plot calculations and experimental plot work, was larger than was originally expected. There was a big attendance representing all provinces except Bombay. This Committee had not been formally appointed by the conference in session, but in view of its representative composition, ("Silviculturists and others interested"), such appointment appeared superfluous. The following Silviculturists were present:—

Mr. Champion (Forest Research Institute).
„ Chaturvedi (United Provinces).
„ Homfray (Bengal).
„ Rowbotham (Assam).
„ Shirley (Burma).
„ Vahid (Central Provinces).
„ Littlewood (Madras) [Provincial Research Officer].
„ Osmaston (Bihar and Orissa) [do.].

Punjab was represented by Mr. Glover.

COMMITTEES.

Experimental and Statistical. Items 1, 2, 3, 6 and 11.	Glossary of Technical Terms. Item 5.	Increment of species without rings. 11 (*a*).	Stump and Stem Analysis. 11 (*b*).	Method of Research on Thinning. Item 11.	Standardisation of Stockmapping Methods and Symbols. Item 15.	Resolutions.
H. G. Champion (Chairman).	C. G. Trevor (Chairman).	H. G. Champion (Chairman).	H. G. Champion (Chairman).	H. G. Champion (Chairman).	H. R. Blanford (Chairman).	H. L. Newman (Chairman).
All Provincial Silviculturists and others interested. (*Vide* names with asterisk on p. 1.)	H. R. Blanford.	C. E. Simmons.	H. R. Blanford.	G. S. Shirley.	C. M. Harlow.	E. O. Shebbeare.
	E. A. Smythies.	M. D. Chaturvedi.	H. M. Glover.	H. M. Glover.	P. C. Osmaston.	S. H. Howard.
	A. A. F. Minchin.	I. D. Mahendru.	C. E. Simmons.	C. K. Homfray.	Sher Singh.	
	G. D. Kitchingman.		I. D. Mahendru.			

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INSPECTION OF ECONOMIC WORKSHOPS.

On the afternoon of Saturday, March 16th, the members of the Conference were shown round the workshops of the Economic Branch of the Forest Research Institute by Mr. H. Trotter, Forest Economist, and his staff.

INSPECTION OF FORESTS OF DEHRA DUN DIVISION.

An excursion was made on Sunday, March 17th, by nearly all members to see the working of the *sal* forests of Dehra Dun Division. As Mr. R. G. Marriott, Divisional Forest Officer, was prevented by illness from conducting the party, Mr. Trevor took charge. Mr. Chaturvedi explained the features of interest of the United Provinces experimental plots which were in his charge. The programme was as follows:—

Meeting-place, 10-30 A.M.

Meet at Asarori, 10 A.M., from Dehra Dun, at the motor-road gate on the Asarori-Phandowala Road.

The appended note on the silvicultural system applied to these forests may be read. [Not published.]

Drive slowly to Halt No. 1, passing the following compartments on the left, in the order given:—

Compartment 3, Asarori P. B. VI.—Worked over as coppice with standards in 1915-16 under old Working Plan. Regeneration fellings in 1924-25, in which most of the overwood was removed (excepting a few trees retained for shelter). Advance regeneration cut back, except for some good groups of poles, in 1925-26; and the area burnt departmentally in March 1926. Thus the young crop is three years old.

Compartment 8, Asarori P. B. VI.—History similar to that of compartment 3. Young crop three years old.

First Halt, 11-0 A.M.

On the boundary of Compartments 8 and 9.

Compartment 8, P. B. VI.—As just described.

Compartment 9, Asarori, P. B. I.—Worked as coppice with standards in 1906-07. Regeneration fellings have just been finished this year under the present Working Plan. Will be cut back next year.

Motor on about one mile to Halt No. 2.

Second Halt, 11-30 A.M.

Between southern part of Mohammadpur compartment 2 and compartment 8.

Southern part of C. 2, P. B. I.—Was not worked as coppice with standards under the old Plan. Regeneration fellings in 1921-22, followed by cutting back in 1922-23. Unlike most of the regeneration areas, this compartment was not departmentally burned after the fellings. Most of the shelterwood has been now removed (this year).

Compartment 8, P. B. VI.—Overwood mostly felled in 1926-27. Cutting back, or thinning where groups were retained, was done in 1927-28. Cut back portions burnt departmentally in April 1928. In some places the groups were too heavily thinned with the result that many young poles were bent over by wind. These have been coppiced back this winter.

Motor on to Phandowala Rest House (about 4 miles). The first part of the way is through parts of the intermediate periodic blocks of the *sal* Working Circle; in these compartments no fellings have been done under the present Working Plan. The last mile is through C. 7 and 8, P. B. II areas; here, too, no fellings have been done under the present Working Plan. These P. B. II areas near Phandowala Rest House have been departmentally

burned in April or May of 1926-27 and 1927-28, with the object of promoting *sal* regeneration and killing back weeds. One of the problems of forest management in Dehra Dun is how to get *sal* regeneration in forests of this kind, which are of good quality and growing on good soil, but where the natural regeneration for the time being consists of valueless weeds such as *Clerodendron infortunatum* and *Millettia auriculata*.

THIRD HALT, 12-15 P.M.

Phandowala Rest House.

Lunch here, or if preferred, first return along the same road ½ mile and continue to Halt No. 4.

Motor from Phandowala to Amsot 3 (about 5 miles) passing through Balindawala C. 11, P. B. I. felled over in 1926-27. The regeneration near the road is poor owing to the proximity of a grazing area: fencing is to be erected shortly. The last mile is off the motor road and it may be necessary to walk part of it.

FOURTH HALT, 1-30 P.M.

Amsot Compartment 3.

P. B. I. Regeneration fellings done last year.

Subsidiary operations (cutting back and departmental burning) this year. The burning will probably have been done before 17th March 1929.

Returning to the cars, motor about 5 miles to Halt No. 5.

FIFTH HALT, 2-15 P.M.

Lachiwala, near the gate on the motor road.

(a) *Experimental Plot No. 21, Dehra Dun Division.*

Dun Sal.—Filling up of P. B. I. *sal* regeneration failures.

Area: 10 acres. Sub-divided into 4 sub-plots:—

21*a*. Teak cuttings put out in March 1928, and left unirrigated.

21*b*. Teak cuttings put out at break of rains, 1928.

21*c*. *Gmelina arborea* cuttings put out at break of rains, 1928.

21*d*. Fenced (Hercules). Game proof. Sowings of *sal* and *Terminalia tomentosa*. Half weeded, half unweeded.

On November 24th, 1928, the enumeration gave the following results:—

Teak cuttings. Height class.	Put out in March. Per cent.	Put out in July. Per cent.
Failed	14	7
1 foot	10	69
2 feet	32	23
3 feet	30	1
4 feet	12	*nil*
5 feet	2	*nil*
	100	100

(b) *Experimental Plot No. 1, Dehra Dun Division.*

Dun Sal.—Regeneration, Study of. Influence of Overwood on 3 sub-plots:—

1*a*. Overwood, *nil*, March 1921.

1*b*. Overwood, 25 trees to an acre, March 1921.

1*c*. Overwood, 25 trees to an acre, September 1921.

To study particularly—

a. Damage by frost.

b. Weed growth.

c. Seedling recruitment.

Two sample plots one in each of the sub-plots 1*a* and 1*b* to study the increment.

Motor about 4 miles to Halt No. 6, passing portable charcoal kilns under trial.

Sixth Halt, 3-0 p.m.

On the metalled road between Lachiwala Compartments 14 and 15.

Lachiwala C. 14 and 15 are both in P. B. II of the *sal* Working Circle C. 14 was burned departmentally in 1927 and 1928 with the object of promoting *sal* regeneration, and the fellings are now being done.

Fellings were made over C. 15 in 1927-28, and subsidiary operations have been done this year.

Motor 10 miles by District Board metalled road to Dehra Dun, arriving Dehra Dun about 4 p.m.

General Note.

Most of this tour will be in areas which have not been badly affected by frost, and it may be questioned whether there is any need to retain even a light shelterwood after the regeneration fellings. On the higher level (*e.g.*, in Asarori and Mohammadpur blocks) it is probably quite unnecessary, except perhaps to guard against abnormally severe frosts. And, when these occur, it is more than doubtful whether even a complete canopy is of any use as a shelterwood. In low-lying parts, frost often does same damage to the young crop in ordinary winters; and it has not yet been decided what kind of shelterwood ought to be retained in such localities. In the compartments that were first felled under the present Working Plan, from 5 to 12 *sal* standards were usually kept, partly as shelter trees and partly as seed bearers. As seed bearers they are not of much practical use: and during the past two years the practice has usually been to fell all, or almost all, the *sal*, and to keep a shelterwood consisting of a considerable number of small trees of miscellaneous species. The idea is that these will be cut out or girdled later on, without damaging the young crop; whereas a shelterwood of big *sal* trees does a great deal of damage when final fellings are made. (We do our best to minimise this damage by lopping the trees before they are felled This costs about 3 annas per tree.) On the other hand, if an accidental fire burns the area in the hot weather, a shelterwood of small trees is liable to be almost entirely destroyed.

As a matter of fact, there is no doubt this clear-felling would in time result in a well-stocked uniform *sal* forest in any part of Dehra Dun Division where there is sufficient established advanced growth. The private forests in the district are evidence enough that *sal* here will in time grow up in sufficient density to produce a full crop, no matter how often its growth is delayed by frost. But frost-bitten *sal* saplings grow up into unsound trees: and one of the chief problems in the Dehra Dun *sal* forests is how to prevent unsoundness from developing in young crops as a result of frost.

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ITEM 1.

RELATION OF CENTRAL AND LOCAL SILVICULTURISTS.

1. (a) Functions of the Central Silviculturist and Staff required.

A paper was presented by the Central Silviculturist, *vide* page 12.

Notes were submitted by Bengal, Bihar and Orissa, Bombay, Burma, the Central Provinces and the United Provinces.

In Committee (Experimental and Statistical Committee), the Central Silviculturist's proposals were accepted with slight modifications after some discussion as to whether a ' Code ' of prescriptions for experimental research would not be preferable (United Provinces) to a ' General account '. As regards staff, the Central Silviculturist stated that he was now promised an I. F. S. Assistant in April, and had obtained the extra clerk required, so that his needs were met for the moment, but further requirements would depend on further calls on him by provinces; the general opinion was expressed that his demands erred in being too moderate.

The Central Silviculturist explained shortly the evidence he had given to the Government of India Committee examining the organisation, etc., of the Forest Research Institute, to the effect that in his opinion, the post of Central Silviculturist should be a Conservator's and should be filled by selection without regard to seniority from officers with experience of research work, *i.e.*, generally from among Provincial Silviculturists; further that whenever possible, an officer intended for a Provincial Silviculturist's post should first put in a year or two with the Central Silviculturist. These proposals met with general approval.

The Committee presented a report to the Conference (*vide infra*). The Conference accepted the report after amending the clause concerning submitting Experimental Plot files to the Research Institute to bring it into agreement with the decision on Item 1 (*c*).

The following resolution was passed; having been proposed by the Central Silviculturist and seconded by Mr. Shirley (Burma).

RESOLUTION 1 (*a*).

RESOLVED *that this Conference accepts the report of the Committee recommending the adoption, with certain modifications, of the Central Silviculturist's proposals.*

Report of the Committee (as amended by the Conference).

The Committee recommends that the relation of the Central Silviculturist to the Provinces be further defined as follows:—

I.—*Statistical.*

1. The Central Silviculturist should continue to undertake all sample plot calculations as a routine measure.

2. The Central Silviculturist should investigate thoroughly methods of forest statistical research, and make proposals for consideration where the need is felt for collection of data.

3. The Central Silviculturist should arrange to give assistance in the field to Provincial Silviculturists on application from them, and thereby keep his staff in touch with forest work.

4. The Central Silviculturist should undertake compilation of yield and volume tables or any other similar work in which help is required by the provinces. If a province wishes for any reason to do such work itself, the connected records at the Research Institute should be made available for the purpose. The Central Silviculturist should also propose a standardised procedure for such operations as lend themselves to it; a revised and ex-

tended Statistical Code is required for this. Resolutions would be passed on these matters at the periodical Silvicultural Conference.

II.—*Experimental.*

5. The Central Silviculturist should make a special study of methods of experimental research and circulate useful information collected. A general guide for the conduct of experimental research on silvicultural problems would be very helpful to research officers in the provinces. It should advisedly include. as a separate part, prescriptions for procedure and for the use of forms where their introduction would be definitely helpful and not a hindrance to individual initiative.

6. The Central Silviculturist should see provincial experimental plot files annually, as far as this is practicable,* to enable him to maintain his records up-to-date, and should record any comments or suggestions he may desire for consideration by the Provincial Silviculturist. He should pay special attention to co-ordination of work and co-operation between provinces in problems affecting more than one province.

7. The Central Silviculturist should similarly see as many of the provincial experimental plots as possible. He should also see other investigations with the same object.

8. The Central Silviculturist should undertake such original investigation work as he can usefully attempt under Dehra Dun climatic conditions and with such assistance as he can be given. Such work should as far as possible be selected from among proposals received from the provinces.

9. Under special conditions, the Central Silviculturist might arrange with the provincial authorities to initiate if not maintain special investigations in a province where the need for them was felt by either party.

The Committee also reports with regard to the staff of the Central Silviculturist, that it considers that requirements must depend on the extent of the help asked for by province under Heads 3 and 9 and it appears that a good deal of help may be asked. It is not found possible to do more than to recommend that the Central Silviculturist's trained staff should be maintained up to the strength found necessary by him to undertake such work.

PAPER

Contributed by

H. G. CHAMPION, *Silviculturist, Forest Research Institute.*

Since the Forest Research Institute was started in 1906, changes in the original scheme and ideas have been found advisable or even inevitable. In none of the five Branches have these changes been more radical than in the Silvicultural Branch. Although several provinces have appointed their own research officers for utilisation (United Provinces, Burma, Madras, Punjab and Bengal) and even botany (Burma) and entomology (Burma), research in the subjects has remained and must long remain largely centralised for the obvious reasons of the need for costly plant, extensive collections and expert staff.

In the case of silviculture, work must mostly be done in the forest, and frequent visits to experimental areas are essential. Even if our organisation was centralised, work would have to be carried out by officers more or less permanently stationed in a province. It was therefore inevitable that as progress was made, the urgent need for a Silvicultural Research Officer should be felt in every province.

The following provinces now have conservators whose special duties are control of Working Plans and Silvicultural Research :—United Provinces (1920), Burma (1921), Madras (1925), and the Central Provinces (1925), whilst in the Punjab, Utilisation is combined (1921).

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* *Cf.* Resolution 1 (c), p. 19.

Silviculturists have been appointed in Burma (1916), United Provinces (1918), Bengal (1919), Madras (1919), Central Provinces (1922), and Assam (1927), Economic as well as Silvicultural research also falling to the Provincial Research Officer of Bihar and Orissa (1921). Thus only Bombay, Punjab, and Bihar and Orissa of the major provinces have yet to follow suit in creating a whole-time post.

Prior to the appointment of these special officers, there was but little organised research on silvicultural problems except that done by the Forest Research Institute Silviculturists, mainly by Messrs. Troup and Marsden. Troup covered a wide field on both experimental and statistical sides, but his monumental work on the silviculture of species was his chief legacy. Marsden gave most of his time to crop growth statistics for which the need was greatly felt. It is not desired to belittle the excellent work done by individual Divisional Forest Officers in all provinces, but the net results were rarely proportionate to the labour expended owing to lack of continuity, frequent transfers, and lack of systematic records. Working Plans were at one time entirely centralised, then entirely provincialised, and more recently again at the 1922 Silvicultural Conference, the arrangement was altered by general consent to allow of the expression of any criticism from the Forest Research Institute before final printing of the plan: the conference delegated this function to the Central Silviculturist, but it was taken over by the Professor of Forestry soon after the creation of that post.

The position of the Central Silviculturist has thus been completely altered since the time of Messrs. Troup and Marsden, but it has not been redefined. There are certain advantages in some respects in leaving things as they are, but in other ways, it would be as well to clarify the situation.

All statistical calculations were relegated to Dehra Dun in the 1922 Conference, and it is unlikely that this excellent arrangement will require alteration. Sample plots are mainly concerned, and their number is steadily increasing; it now stands at 986.

There is, however, another aspect of this statistical side of our work which is becoming more urgent for attention. Our present methods as concerns sample plots in even-aged forest are the outcome of the labour of Messrs. Troup, Marsden and Howard, being an adaptation of Schwappach's method largely used in Europe. It would not be claimed that this is fixed for ever and incapable of improvement; moreover, even-aged sample plots can only concern at most the 1,600 sq. miles (=·007 per cent.) of our total area which are under uniform systems, leaving an enormous field of work for the other forests, and in other directions for regular or semi-regular forests. The need now exists for a critical study of the ever increasing literature on the subject and systematic research in this direction.

The writer is strongly of opinion that the statistical section of the Central Silviculturist's staff should and most usefully can put in 2—4 months annually in the field: it keeps them in touch with the practical side of the work and there is no end of work to be done; he therefore hopes that this opinion will be confirmed and acted on. The Statistical Assistant must in any case keep closely in touch with field work, and he must be able to test in the forest as well as in the office any improvements or new methods under consideration. The Statistical Lower Grade Assistant would supervise the field work and probably carry out other statistical work in the same area. It should also be of great utility to provinces if the central statistical staff were on occasion available to them with a field party to finish off or assist in any field work requiring trained staff, as in the case of recent visits to Bengal and Madras, and this may be considered.

As regards the nature of the field work to be done, it is suggested that during the rains the Central Silviculturist should circularise Provincial Silviculturists stating staff available and on receipt of replies, decide where it could be most useful. To give maximum assistance, the method of work must, it will be felt, largely be settled by the officer asking for the assistance, but the Central Silviculturist should be given the opportunity of noting on proposed procedure and the men would have to remain responsible to him.

A good deal is already being done towards compilation of general and local volume tables, but the question of travelling expenses is likely to rule out any such work in provinces other than Punjab, United Provinces, Bengal, Bihar and Orissa and Central Provinces, in the first three of which such work has so far been done.

It is obvious that the Central Silviculturist can only act in an assisting and advisory relationship to his confrères in the provinces. It is therefore essential that he shall himself have had experience as Provincial Silviculturist, and this should be made a *sine qua non* of the appointment. It has repeatedly been urged in the provinces that the Silviculturist should be a senior officer with ample divisional experience so that his advice carries weight with the territorial staff, and if this is true in a province, it is doubly true in the Central Research Institute—but in practice it has often been found impossible and so nothing more can be said.

The position as regards experimental plots remains undefined, but will it is hoped be clarified by the present conference. Any calculations required can be dealt with by the statistical staff, and beyond that it is unlikely that anything more can usefully be done except a perusal of the files by the Central Silviculturist with a view to suggestions for improvement in procedure and recording, so technical staff is not in question.

The present situation being that the Central Silviculturist lays out no sample plots or experimental plots except at the request of a province and in order to hand them over for maintenance, it remains to consider what field research work is left to him. Two courses may be suggested: that he should take up special problems for which the Provincial Silviculturist has no time or facilities; or, that he does none at all. If he does none, he may remain at headquarters virtually as head of a bureau of information, with centralised calculation and checking of plot records from the provinces, and may wonder why he has spent so many years training as a practical forest officer. This is surely a most undesirable arrangement. The better alternative is that he shall undertake such Silvicultural Research work as lends itself to combination with his other duties, and can be controlled through an assistant in his periods of absence on tour. He should also see as much as possible of the field work in the provinces, to give the assistance which his wider experience and special study should enable him to give. He ought above all to pay special attention to methods of research with a view to constant progress in this direction.

The position has already evolved that one of the chief functions of the Forest Research Institute is as a bureau of information as already mentioned. This function cannot be intelligently carried out without first-hand knowledge of the forests and problems concerned, so on this ground also a lot of touring is necessary—say 5—6 months annually. Continuity over a fairly long period is an essential to almost all our research, and so he must have the necessary assistance available to him for carrying on work during these absences.

We can now say we have a satisfactory system of collecting and recording information, but with the present staff it cannot be done as well as it ought to be. There are two phases of this work, one is the collection of the information and the other is combining it with what already exists, and so having it in a form ready for use. For the former, we are short handed: what can be done by a clerk is relegated to him (most publications in standard form—annual reports, etc.); assistance is taken from the Upper Grade Assistants as far as possible, but a great deal inevitably falls to the Silviculturist, and it is a big task. Particularly with the foreign literature the need for help is felt, but with a qualified Assistant Silviculturist the position would be alleviated for the present. Actually it is a whole-time task at least for a couple of years to bring our general files into such condition that their continuance could be viewed as an ordinary routine matter. What is really required is a book on Indian Silviculture by subjects, comparable to Troup's by species, as a starting point to which to refer, and on which to build further.

SUMMARY.

It is proposed that the position of the Central Silviculturist with regard to the Provinces be further defined, and that the following are the *desiderata*:—

I.—*Statistical.*

1. The Central Silviculturist should continue to undertake all sample plot calculations as a routine measure

2. The Central Silviculturist should investigate thoroughly methods of forest statistical research, and make proposals for consideration where the need is felt for collection of data.

3. The Central Silviculturist should arrange to give assistance in the field to Provincial Silviculturists on application from them, and thereby keep his staff in touch with forest work.

4. The Central Silviculturist should undertake compilation of yield and volume tables or any other similar work in which help is required by the provinces. He should also propose a standardised procedure for such operations as lend themselves to it; a revised and extended Statistical Code is required for this. Resolutions would be passed on these matters at the periodical Silvicultural conferences.

II.—*Experimental.*

5. The Central Silviculturist should make a special study of methods of experimental research and circular useful information collected. A general account should be written up and published.

6. The Central Silviculturist should see provincial experimental plot files annually to enable him to maintain his records upto date, and should record any comments or suggestions he may desire for consideration by the Provincial Silviculturist.

7. The Central Silviculturist should similarly see as many as possible of the provincial experimental plots and other investigations for the same purpose.

8. The Central Silviculturist should undertake such original investigation work as he can usefully attempt under Dehra Dun climatic conditions and with such assistance as he can be given. Such work should as far as possible be selected from among proposals received from the Provinces.

9. Under special conditions, the Central Silviculturist might arrange with a Provincial Silviculturist to initiate if not maintain special investigations in a province where the need for them was felt by either party.

III.—*Records.*

10. One of the main functions of the Central Silviculturist must be the maintenance of records as complete as possible of all available information bearing on Indian Silviculture, and the supply of this information to workers in the provinces.

* * * * * * *

Staff of Central Silviculturist.

The 1922 Conference passed a resolution recommending the following staff:—

1 Imperial Assistant, Statistical.
1 Imperial Assistant, Experimental.
1 Imperial Assistant, Ledgering.
1 P. F. S. Assistant for each.

This was rather over-ambitious, and although one post of Imperial Assistant has been provided for for several years, it was finally quietly dropped out when the Professor of Forestry was appointed. For an appreciable part of the time since the conference, the staff has been actually less than formerly as there was only one Upper Grade Assistant.

The increase in the work since 1922 may next be considered. The numbers of sample plots on the books have been as follows:—

1922.	1923.	1924.	1925.	1926.	1927.	1928.
379	487	631	709	806	866	986

The number of calculations required will not appreciably alter till the total is doubled, owing to the shifting after the 1, 2 or 3 measurements to a 10-year basis. The existing staff (1 Head Computer, 4 Computers and 4 Field Assistants) will probably be adequate for some time longer.

The number of Experimental Plots similarly has increased—

1922.	1923.	1924.	1925.	1926.	1927.	1928.
95	109	162	279	357	432	(432)

and of course the appointment of more provincial research workers means more and more plots.

In 1922 we had 764 specific ledger files and we now have 1,010. Troup wrote his classic book in 1921 on 3 cabinets of files which were then closed: since then the accumulations have filled 12 cabinets which are already overcrowded.

Again in 1922 we had a few general ledger files very haphazardly maintained, and we now have 242. At that time about 120 issues of periodicals were dealt with annually and the number is increased now to 320.

It must be realised that the eminently desirable decentralisation of research work has not decreased, but greatly increased the work of the Central Silviculturist, and also naturally calls for an even higher standard of work.

The present technical staff consists of—

Central Silviculturist.

Upper Grade Assistants.—Two, one primarily on statistical work and the other on experimental work.

Statistical Section.—1 Lower Grade Assistant (Head Computer), 4 Computers, 4 Field Assistants, 1 Surveyor.

Experimental Section.—1 Field Assistant, 1 Nurseryman, 1 Seed Collector, 1 Artist.

Records.—1 Ledger. Clerk, 1 Photographer.

This staff is inadequate to undertake the work falling to the branch. A competent assistant from the Imperial Forest Service is urgently required to share the excessive amount of work at present falling to the Central Silviculturist personally and the proper maintenace of the records would be one of his chief duties. It is mainly to ask for a resolution recommending such an appointment that the question has been brought up. The records also require a second permanent clerk, mainly to help with typing, but also to ensure our having a trained relief to the present man. If any investigations are undertaken outside Dehra Dun, the experimental staff would require strengthening, and a Lower Grade Assistant in this section could also very usefully be employed.

1. (b) Staff for Provincial Silviculturists.

Papers were presented by Mr. C. K. Homfray, Silviculturist, Bengal, and Mr. S. A. Vahid, Silviculturist, Central Provinces (not reprinted).

Notes were submitted by Bihar and Orissa and Assam.

In Committee (Experimental and Statistical Committee), Mr. C. K. Homfray summarised the papers and notes, and from the discussion following it was evident that the opinion was generally held that the sample plot field party was the important unit, one full party being the minimum staff possible for a Silviculturist to justify his post. The constitution of such a party in the several provinces was compared and the most suitable form deduced. There was some discussion also as to how experimental work should be fitted in with the statistical, and the conclusion was reached that, as a rule, the two classes of investigation required to be done at different seasons of the year and there was no difficulty in combining them, though in some cases an extra man is required throughout the year in charge of experimental gardens or nurseries.

It was found that provinces viewed the question of special allowances for Rangers and Foresters in various ways. All members were of opinion that Rangers should get a special allowance of pay Rs. 15 to Rs. 25 per mensem, but for Foresters conditions were found to vary more, some being on the provincial cadre and others only temporary or directly recruited. The majority of the Committee favoured recommending an allowance of Rs. 5 to Rs. 15, but Burma and Bihar and Orissa members disagreed.

The Committee presented a report to the Conference (*vide infra*), and in debate it was decided to adopt the report, except that whilst a recommendation that Rangers and Foresters should be given special allowances was acceptable, all mention of the amount of such allowances should be omitted.

Mr. Barrington (Burma) drew attention to the importance of continuity of service in research work.

The following resolution was proposed by Mr. Homfray (Bengal) and seconded by Mr. Vahid (Central Provinces), and passed by the Conference:—

Resolution 1 (*b*).

Resolved *that this Conference accepts the report of the Committee as amended in debate that the minimum staff required for a Silviculturist is a full sample plot field party and two clerks. A field party is one Provincial Service officer or picked Ranger, and 3 men of the Forester type. It is further recommended that Rangers and Foresters of the Provincial cadre on duty with the Silviculturist should get a duty allowance of some sort, and that each Silviculturist should have a Gazetted Assistant.*

Report of the Committee.

As requirements and possibilities must always vary with the very different conditions prevailing in the several provinces, the Committee considers that it is impossible to lay down any general scale for staff. It wishes, however, to express its opinion as to the minimum staff required to ensure that the Silviculturist is in a position to do his work satisfactorily. This minimum consists of a full sample plot field party of one Provincial Service officer or picked Ranger, and three men of the Forester type. The Committee strongly recommends that a man of Deputy Ranger status should also be provided as an understudy to the head of the party and to do such parts of the work as the surveying.

Further, the Committee wishes to stress the point that a smaller staff than this minimum results in waste of time, talent and money, in that men on high pay have to do such work as painting numbers on trees which could be done just as well by the lower grades.

Two clerks are considered the absolute minimum for efficiency, one for ledger files and other records, and one as a typist or tour clerk.

The statistical party can also do any experimental work required, and as the work increases, the need for a second party should be considered.

It is recommended that Rangers and Foresters on the provincial cadre on duty with the Silviculturist should draw a special duty allowance.

The Committee considers that every Silviculturist should have a Gazetted Assistant to relieve him of routine work and to serve as understudy ensuring continuity of work.

1. (c) Procedure with regard to Experimental Plot Files.

Papers were presented by Messrs. Shirley (Burma) and Vahid (Central Provinces), and the Central Silviculturist.

Notes were submitted by Burma, Bihar and Orissa, the Central Provinces, the United Provinces, Bombay and Assam.

In Committee (Experimental and Statistical Committee), papers and notes were summarised by the Central Silviculturist, to the effect that Assam, Bengal, the Central Provinces and the United Provinces were willing to send in their files once annually to the Central Silviculturist for perusal; Bombay considered that the resumé in their Annual Reports should suffice, whilst Burma considered the proposal impracticable in view of the inevitable delays involved. To the suggestion that each province should decide whether to send all the files as a routine measure, or whether only selected files should be sent, Madras, Bihar and Orissa and Assam agreed to the former procedure, and Burma, the Central Provinces, the United Provinces and Bengal the latter, Punjab leaving decision till later, and Bombay not recording an opinion. The suggestion by Mr. Shirley (Burma) in his paper that, as far as possible, deductions from experiments should be referred before publication to the Central Silviculturist for his opinion, was supported by all present.

The Committee submitted a report to the Conference which was accepted without debate.

The following resolution was proposed by Mr. Osmaston (Bihar and Orissa) and seconded by Mr. Minchin (Madras) and carried unanimously.

Resolution 1 (*c*).

Resolved *that this Conference accepts the proposals of the Central Silviculturist as modified by the Committee.*

Report of Committee.

The procedure proposed by the Central Silviculturist is recommended for adoption with two amendments. This procedure so amended is as follows :—

(*i*) A copy of Form 2 should be sent to Research Institute as soon as a plot is laid out.

(*ii*) As a rule, the complete experimental plot file should be sent in original to the Research Institute once a year so that all records of which a copy is wanted can be copied; a covering letter (this could be a printed form) would give the latest date by which the file must be received back (whether copied or not) by the Provincial Officer. To distribute the work, files should as far as possible be sent off after inspections instead of being allowed to accumulate. Any calculations or checks would be made during the course of copying. Where the Provincial Silviculturist finds this arrangement inconvenient, the file should only be forwarded if he considers it of general interest, or if on seeing Form 2, the Central Silviculturist asks for the complete file.

(*iii*) When an inspection note of unusual interest has been added to Form 2 continued, a copy should be sent as soon as possible.

(*iv*) Records of Silvicultural Garden and miscellaneous experiments and investigations need not be sent in, but a copy of Form 2 should be submitted as soon as a new investigation using it is opened: a copy of Form 2*a* is also required annually. Copies of any other Summary forms which may be adopted in accordance with the proposals made for standardising methods of dealing with experimental plots, should be sent when the investigation is completed, or the file containing them should be sent in like an

experimental plot file for copying portions required. Records of germination tests could be sent in in the same way once a year, all at one time.

(*v*) The files of statistical experimental plots should be submitted like those of sample plots after a measurement, and for such types as are not codified, a note will be required as to calculations desired, etc. The same applied to miscellaneous statistical investigations.

(*vi*) When possible, deductions drawn from experiments should be referred to the Central Silviculturist for criticism before publication.

1. (d) Photographic Collections.

Papers were presented by the Central Silviculturist, *vide* page 22, and Mr. S. H. Howard (United Provinces), *vide* page 25.

Notes were submitted by Bihar and Orissa, Bombay and the Central Provinces.

In Committee (Experimental and Statistical Committee), the Central Silviculturist summarised the papers and notes. It was agreed that a uniform classification of photographic records was advisable. Delegates from Bihar and Orissa, the Central Provinces, Madras and the United Provinces, were desirous that the Research Institute should undertake their developing and printing work, on payment if necessary, whilst other provinces prefer to do their own work either themselves or locally. The Central Silviculturist said that for the present he could and was willing to undertake the amount of such work that was likely to be sent to him, but that he was not in a position to give any general undertaking in the matter.

The question of storing negatives at Dehra was discussed at some length as also the best arrangements for mutual help with regard to supplying prints of special interest, and proposals were made. Bengal, Bihar and Orissa, Madras, the Central Provinces and the United Provinces expressed a wish to store negatives at the Research Institute, and Punjab and Burma not to do so.

Mr. Osmaston (Bihar and Orissa) made the suggestion that in return for the work which the Central Institute was to do for the provinces, the former should have the right to use the photos sent in for publication. This suggestion was supported by Mr. Blanford and others, but the Central Silviculturist said he considered it unnecessary to lay this down, and that he preferred to ask permission when occasion arose, so the matter was dropped.

No one present was willing to undertake the compilation of the manual called for, but it was suggested that Messrs. Smythies and Minchin should be approached.

The Committee presented a report to the Conference in the form of a modification of the Central Silviculturist's proposals. There was no debate except on the point of storage of negatives, the desirability being stressed of leaving it optional to provinces to make use of the facilities at Dehra Dun, or not, as they preferred.

As regards the manual, it was left to the Central Silviculturist to do what he could. Mr. Smythies offering to criticise any draft sent to him for the purpose. It was suggested that the Central Silviculturist should correspond with Messrs. Troup, Cox, Wright. Gilbert, and F. W. Champion on the subject.

The following resolution was proposed by Mr. Glover (Punjab) and seconded by Mr. Garland (Bombay), and passed by the Conference :—

Resolution 1 (*d*).

Resolved *that this Conference accepts the proposals of the Central Silviculturist as modified by the Committee and in open debate.*

Proposals as accepted.

1. Every Silvicultural Research Office should have a good camera suitable for forest work.

2. Every Silvicultural Research Office should have a classified collection of photographs. The classification should as far as possible be uniform.

3. Every Silviculturist should himself photograph unless one of his staff can do it, and should look upon the camera as an indispensable recording instrument for experimental plots and the forest generally.

4. Each Provincial Silviculturist should send in annually to the Central Silviculturist a direct print of each photo likely to be of general interest, which has been added to his collection during the year. The amalgamated

collection of photos from all Provinces should be circulated to Provincial Silviculturists with a note for each as to where the negative is stored. The Provincial Silviculturists would write direct to the officer holding the negative for any prints required by them. The Central Silviculturist will similarly ask for any prints required by him, and these would be supplied on his standard size (Full plate).

5. The Research Institute should store negatives for those Provinces which wish to place them in his charge. Such negatives would be returned by the Research Institute if at any time the Province should wish to store its own collection.

6. The Photo Section at the Forest Research Institute should afford all possible assistance with photographic work in this connection.

7. The Central Silviculturist should maintain as complete a collection as possible of foreign photos and slides of general silvicultural interest.

8. As opportunity offers, trials should be made under forest conditions of possible improvements such as stereoscopic views, special appliances, etc., results obtained being circulated for information.

9. A short manual dealing with photography in the forest under Indian conditions is required. It could best be compiled by the collaboration of officers having special knowledge and experience of the subject.

PAPER (*i*)

Contributed by

H. G. CHAMPION, *Silviculturist, Forest Research Institute.*

Besides the Central Silviculturist, only the Burma and the United Provinces Silviculturists are known to have any regular collection of photographs. Before making proposals for co-operation in the matter in the office, it may therefore be as well to review briefly the value of such a collection, the sources on which one can draw for it, and the best methods of dealing with the photographs.

1. *The use of photographs.*—The chief value of photography to the Silviculturist lies in the fact that the camera is a recording instrument of greatest utility in research work. It can help in more ways than one. The most straightforward is through the assistance which a photograph gives in recalling a mental picture of some part of the forest in which investigations are in progress, doubly valuable if it happens to be a part which one has not visited or cannot visit. A photograph will rarely or never satisfactorily *replace* the written record, but it is hardly too much to say that the latter is but seldom able to call up to most people anything approaching an accurate mental picture. Furthermore, the photograph records a vast amount of detail which appears of no importance when the written record is made, but may be required at some later date. Again, when two plots not near to each other have to be compared, a pair of photographs is very helpful, differences being at once apparent which might easily be overlooked when one is standing in the one and trying to recall the appearance of the other. Still greater is the value of a photograph when the time factor comes in, and one wishes to know what an experimental plot looked like, say last year, or a longer time ago: no amount of figures and description will serve so well as a pair or series of photographs taken from the same spot. Even if the photos differ more or less in view-point, size and so on, they may be extremely helpful, despite the well-known dangers of using photographs of such subjects as part of a plantation.

For these reasons, it is desirable that whenever possible written records should be supplemented with photographs. This applies particularly to experimental plots and indicator plots, care being taken so to select the view that with the expected development, it can be taken again later on from the same side and will include some readily recognisable object.

The other aspect of the utility of a photograph is from the point of view of education and propaganda. Results obtained from silvicultural

research require to be published in such form as to be readily grasped by those—probably unversed in research methods—who should apply them. A good photograph helps greatly in this direction, and may obviate a lot of written description. A good example may be seen in Smythies' Forest Record on the Afforestation of the Etawah Ravines. A glance at such a pictorial representation will often make the difference between a perusal of the written matter, and its being put aside from lack of interest—a psychological fact one cannot afford to overlook.

Beyond the circle of foresters by profession and interest, comes the wider public (only too often controlling the purse-strings) who have to be convinced of the real utility of some threatened aspect of current forest policy, or of some proposed innovation. These people cannot usually be taken to the forest to see the actual thing and we can bring the forest to them in no other way than as a carefully taken photograph. Even those who doubt what they see in print-type are usually ready to believe what they see as a photographic print, and a little exploitation of the camera's known tricks may be deemed justifiable. Forest Administration Reports are to some extent concerned here, and a good example of the use of photographs with them may be seen in the Burma reports of recent years. Requests have been received recently at the Forest Research Institute from two provinces for lantern slides of forest subjects, silvicultural as well as exploitation, for lectures to interest the public in forestry.

Before leaving this subject the demand for photographs in other countries may be mentioned: the Forest Research Institute has had such requests recently from Java, Australia, England and the United States of America. Most countries which are progressive in forest matters maintain forest photographic collections, that in the last mentioned country being very fine.

2. *Sources of Photographs.*—Five sources of supply deserve individual attention:—

(*a*) Photographs taken by the Silviculturist himself.

(*b*) Photographs taken by his confrères in other provinces.

(*c*) Photographs taken by other forest officers at the request of the Silviculturist or independently.

(*d*) Photographs taken by other persons willing to give prints or lend negatives.

(*e*) Photographs reproduced in publications.

Every Silviculturist ought to have a good stand camera, preferably taking plates and not too small, but convenient for use on tour. A good photographer is probably usually born and not made, but any one can get at least fair results by observing a few very simple rules of procedure for selecting the view to be taken, the stop to use and the exposure to give. It is best to do every thing oneself as far as the negative—leaving printing, enlarging, etc., to the professional if preferred.

The camera should always be taken along on tour and every opportunity seized of getting useful photographs. Every experimental plot and indicator plot should be considered from this point of view: some admittedly do not lend themselves to being photographed, though a little preliminary clearing work or building a *machan* will often do the trick: most present no special difficulty except that one is not always on the spot when intensity and direction of light, and wind, are all favourable. Crops are most difficult to photograph at all convincingly and photographs of sample plots are perhaps often of less value than those of experimental plots, but excellent photographs have been taken of some and the difficulties exist to be overcome.

Good illustrations of forest types, of typical specimens of each tree species in its various seasonal and developmental stages, of the effects on trees and crops of external agencies and influences are always useful, and so difficult to get at short notice that no chances casually encountered should be lost. Clear fellings in progress may offer unique chances of photos of single trees of a type rapidly disappearing never to be regrown. The Silviculturist of

one province can greatly help those in other provinces, particularly as regards photographs of general subjects, by supplying prints of interest to them. This could probably best be done by circulating annually a collection of prints of the photographs taken during the year. Copies required could be made all at one time either at a shop, or if the negatives were sent in, at the Forest Research Institute Photographic Section.

There are in every province at least one or two forest officers who are interested in photography—some are experts at it as in Burma and the United Provinces—and others who are ready to take it up if they are brought to see the direct value of it. The Silviculturist on his own tours has usually only one chance at every given place, and any of a dozen factors may spoil it for him, whereas the local officer can choose his time more or less. The Silviculturist should therefore always get as many people as possible interested: the results will vary enormously in quality, utility, size and so on, but this can usually be got over by selecting the best negatives and getting a copy of them made on a standard size.

Forest officers are not the only people who photograph: one meets keen *shikaris*, planters and others, who have taken photographs which would be quite useful to us. Here again the chance should not be missed and incidentally a collection of rather more general subjects may come in for propaganda purposes.

The last source mentioned is the illustrations given in publications. Unfortunately these are few in India, but the "Indian Forester" not rarely reproduces photos, the originals of which are not available, and there are photographs taken in the forests on the Continent and elsewhere, particularly useful for illustrating silvicultural systems and forests which have been longer under intensive management than ours have.

3. *The Photographic Record in the Office.*—In his "System of Filing Information on Forestry", 1927, pages 42—45, Mr. Howard describes the method of dealing with photographs introduced by him at the Forest Research Institute and on page 2 refers to the unsatisfactory procedure it superseded. When he wrote this, the idea was in its infancy, and even now much still remains to be done before the transference from the old albums to the new cabinet system is complete. It may be mentioned that adherence to a standard size of print (full plate $6\frac{1}{2}'' \times 8\frac{1}{2}''$ at the Forest Research Institute) has great conveniences though by no means essential to the scheme; also that references to the collection by subjects are found to be more commonly required than references to the collection by species.

The only simple alternative to this system is to file photographs on each specific and general ledger file somewhat as is done in most Herbaria. There are certain advantages in this method, but they are more apparent than real and Howard's system is strongly recommended, supplemented by a form on the ledger files giving the titles of photos in the photographic collection.

Every experimental plot and sample plot or other research file for which photos exist, should include a print of each, because such photos lose much of their potential value if they are not in the Silviculturist's hands when he is making an inspection and bringing the record up-to-date.

Many photographs are required both in the general and the specific collections, and often under more than one head or species name: in such cases extra prints should always be made available, as avoidable cross references deprive the system (or *any* system) of much of its value.

If a standard size of print is adopted, as is recommended, there is always the choice when dealing with a negative of some other size, between making a new negative of standard size or of making the required number of prints in an enlarger. It will be found most satisfactory to make new negatives only from picked originals of such exceptional quality and utility as is likely to result in future need for prints, and of course from all negatives shewing signs of deterioration and not yet replaced by later and better ones.

4. *Co-operation.*—In our present stage of development, only the Forest Research Institute possesses a permanent photographic staff which can under-

take all forms of photographic work. The provincial officer has to do his work himself or turn to the bazar shop. The latter course is liable to result in the spoiling of many potentially good negatives, with a wasting of all the time taken getting them, and in resultant discouragement; the exposed plates have also either to be sent by post or dâk-runner, or kept some time before development, again with inevitable losses. Development should, whenever possible, be done in camp soon after exposing the plates, an additional advantage being that one can be sure the fixing and washing is thoroughly done. It is the negative which really matters, for prints, slides, etc., badly made from it, can always be replaced, even if with trouble and cost, provided the negative is a good one and properly looked after. Enlarging, printing, copying making lantern slides and all similar work, take a lot of time and can well be centralised. At present, the Forest Research Institute is doing a certain amount of work of this kind, and it appears to offer advantages sufficient to be worth developing until provincial officers can have similar facilities at their disposal. The one objection is the likelihood of an occasional negative getting broken in the post: this does happen, but out of 200 negatives received and despatched, only 6 have been cracked or broken, necessitating preparation of a new negative from a print.

It is therefore suggested that—

1. Every Silvicultural Research Office should have a good camera suitable for forest work.
2. Every Silvicultural Research Office should have a classified collection of photographs.
3. Every Silviculturist should himself photograph unless one of his staff can do it, and should look upon the camera as an indispensable recording instrument for experimental plots and the forest generally.
4. The Central and Provincial Silviculturists should circulate annually copies of prints of any photos likely to be of general interest which have been added to their collection during the year, to all silviculturists for noting if prints are required.
5. The Photo Section at the Forest Research Institute should afford all possible assistance with photographic work in this connection.
6. The Central Silviculturist should maintain as complete a collection as possible of foreign photos and slides of general silvicultural interest.
7. As opportunity offers, trials should be made under forest conditions of possible improvements such as stereoscopic views, special appliances, etc., results obtained being circulated for information.

PAPER (*ii*)

Contributed by

S. H. HOWARD, *United Provinces.*

The Central Silviculturist should have as complete a collection of photographs as possible. He has already a very fine collection and the problem of classification has been solved. There is no doubt whatever that photography is a most valuable addition to research work more especially if care be taken to record the position from which the photograph was taken so that subsequent photographs can be taken from the same place. Some sort of scale should be visible whenever possible.

It is convenient to have all photographs full plate size and photographs of any other size received should be copied at once on to full plate. If they are not good enough to stand the necessary enlargement they are seldom worth having.

Provinces should have also as complete a set of photographs for their particular province as possible. Whenever a province takes a photograph it should be sent to the Central Institute to see if they want a copy and if so they can make one. If they already have a better one they can return it. Too many duplicates are not wanted. The Central Institute should circulate a list of what it has and if any province needs a copy the Central Institute should supply it. This will avoid a lot of unnecessary duplication in the provinces for the Central Institute has a number of photographs which are so good that there is no point in repeating them.

I should also like to suggest a further stage. The experience in the United Provinces has been that they find it impossible properly to store their plates. It is difficult enough at Dehra Dun with constant supervision but far easier there than elsewhere.

As the Central Institute are always prepared to supply copies of any photograph wanted, I consider it would be preferable if all negatives were sent to Dehra Dun for storage. With the system of exchange indicated it would avoid a great many difficulties and would be just as convenient for most provinces, with Burma possibly an exception. Here again if negatives of odd sizes are received it would be preferable to prepare full plate negatives from them and to destroy the originals.

This does not affect the size of reproduction for printing as the press can get a better result by reducing.

This system would be greatly facilitated by a uniform classification throughout India and Burma.

I am framing no resolution as this is only a basis for discussion and there may be a good deal of discussion. If, however, the conference can crystallise its ideas I am prepared to frame resolutions to give effect to their wishes.

ITEM 2.

ADOPTION OF HOWARD'S FILING SYSTEM IN SILVICULTURAL OFFICES.

Papers were presented by the Central Silviculturist, *vide* p. 28, and Mr. Vahid (Central Provinces).

Notes were submitted by Bengal, Bihar and Orissa, Bombay, Burma and the Central Provinces.

In Committee (Experimental and Statistical Committee), the Central Silviculturist summarised the opinions received from provinces to the effect that there was general agreement that a uniform system was desirable, and that Howard's was the best brought forward hitherto.

Mr. Homfray (Bengal) said he considered it was asking a lot of the small staff of most Provincial Silviculturists to ask them to keep up General as well as Specific Ledger files and that he thought that Specific Files would serve his purpose. It was pointed out that a beginning could be made with a very few General files while the records were few, but that it is precisely these that require a good system as the office grows with time.

Mr. Newman (Bombay) had expressed the opinion that filing was unlikely to be of any appreciable importance in Bombay in the near future as not more than 25 subjects would be in hand at one time, but no Bombay delegate was present to explain how this affected the question.

Mr. Shirley suggested that where some other system was in force and working well, it should not be made compulsory to change over at once: in Burma they recognised the superiority of Howard's System but changing over will take a long time. It was realised that if a change was to be made, the sooner it was made, the better. but it was agreed to make adoption optional if an equally good system was already in use.

The Committee reported to the Conference recommending acceptance, with slight modifications, of the Central Silviculturist's proposals. (*Vide* p. 28).

There was no debate, the conference accepting the Committee's recommendations, and the following Resolution was passed unanimously. (Proposed by Mr. Champion, seconded by Mr. Shirley).

Resolution 2.

Resolved *that this Conference recommends the adoption of Howard's Filing System for Silvicultural records in all provinces, with the proviso that it should not of necessity displace an equally good system already in use. The Conference also accepts the detailed recommendations of the Committee in the appended report.*

Report of the Committee.

The Committee accepts the conclusions reached in the Central Silviculturist's paper with slight modifications. The recommendations then stand as follows:—

1. Howard's Filing System should be adopted for Silvicultural records in all provinces. *It should not, however, necessarily displace* an equally good system already in use.
2. Further sub-division when needed should be effected under the arrangement described in the above quoted paper paragraph 5*.
3. Alterations, if any, should be made by the Central Silviculturist with the agreement of the majority of Provincial Silviculturists.

* Authority for the adoption of further sub-division should be vested in the Central Silviculturist. Whenever a provincial officer proposes to sub-divide any sub-head, recommendations should be sent to the Central Silviculturist, and he could accept them as received, or negotiate amendments if he thought desirable, particularly if other proposals had been received from another province.

4. New editions of the Classification and Index should be printed from time to time whenever the number of correction slips becomes inconveniently large.

Paper

Contributed by

H. G. Champion, *Silviculturist, Forest Research Institute.*

In 1927, Mr. Howard's " System of Filing Information on Forestry " was published, and it is assumed that those interested will be familiar with what is written in the pamphlet.

2. The system was of course devised primarily for dealing with the records collected in the Silviculturist's office, and its application has been under test for over two years here. The change from the preceding system is even yet not complete, but as has been pointed out in the Introduction to the pamphlet, the system is proving very satisfactory.

3. Exact uniformity of method in the offices of the Provincial and Central Silviculturists is not necessarily essential, in fact, one or two points have already come to notice, where modifications might be, for the time being, more convenient in the provincial office. Thus the adoption of this system is recommended not so much on the grounds of ensuring uniformity, as for the reason that the system is the outcome of a careful study of the whole subject and the various possibilities open to us. It represents a combination of the best points of the known methods, and still better has been given a fair test in practice and found good. It is therefore almost certain to be better than any other system devised locally with more restricted facilities for benefiting by the experience of others.

4. A strong point of the system is its adaptability to the records of a silvicultural office whether just initiated, or already grown to the size of the central office with 1,010 specific and 266 general files. It is the inevitable growth of the volume of the records that proves the undoing of other systems, for with few records, almost any or no system will serve.

5. As mentioned above, the special feature of the system is its expansibility. Since the pamphlet was published, sub-division has proved necessary and been effected in many sub-heads, and many titles have been added to the general index. If provincial offices adopt the system, a procedure is advisable for maintaining uniformity. This can readily be provided for, if authority for adoption of further sub-division be vested in the Central Silviculturist. Whenever a provincial office proposes to sub-divide any sub-head, recommendations should be sent to the Central Silviculturist who could accept them as received or negotiate amendments if thought advisable, particularly if other proposals had been received from another province. Annually a list of such sub-divisions and of additions to the index, would be circulated to all concerned and form part of the standard system. New editions of the Classification and Index would be printed from time to time.

6. Alterations are on a different footing, and should only be made on very good grounds: if any are necessary, the sooner they are made, the better. They might be made by the Central Silviculturist with the agreement of all or of the majority of Provincial Silviculturists, or only by the Silvicultural Conference.

It is therefore recommended that:—

1. Howard's system should be adopted for the Silvicultural records in all provinces.
2. That further sub-division when needed should be effected under the arrangement described in paragraph 5 of this note.
3. That alterations should be effected under one of the alternatives listed in paragraph 6 of this note.

ITEM 3.

SILVICULTURAL LIBRARIES.

Papers were presented by the Central Silviculturist, *vide* p. 30, and Mr. S. H. Howard, *vide* p. 35.

Notes were submitted by Assám, Bengal, Bihar and Orissa, Bombay, Burma, and the Central Provinces.

In Committee (Experimental and Statistical Committee), the Central Silviculturist summarised the papers and notes received, and discussion mainly centred round the bibliographical and abstracting work which is to be taken up by the Imperial Forestry Institute at Oxford. Mr. Champion said that this would be very useful to us in India particularly for books and articles in the less known languages, and for the less seen publications; it would not however get over the necessity of perusing the greater part of the literature from the point of view of forestry in India.

The committee submitted a report to the Conference (*vide infra*).

The debate also touched on the assistance expected from the Imperial Forest Institute, the Chairman (who was present at the Empire Forestry Conference in Australia) further explaining the proposals for a Forestry Bureau at Oxford (*cf.* p. 36).

A number of additions and a few alterations were suggested for the lists of books given in the Central Silviculturist's paper, which were accepted by him, and he announced that if the conference thought the lists useful, and in the main correct, he would submit them to a thorough revision before republication.

A resolution, proposed by Mr. Chaturvedi (United Provinces), and seconded by Mr. Ishwar Das Mahendru (Forest Research Institute), was passed as follows:—

RESOLUTION 3.

RESOLVED *that the report of the Committee be accepted.*

Report of Committee.

The Committee makes the following recommendations:—

1. A new catalogue of the Research Institute libraries is needed.
2. The Research Institute libraries should provide for issuing books on loan to forest officers in the provinces, particularly to research officers.
3. The Central Silviculturist should see to it that an annual list of important forestry publications added to the Research Institute Libraries is issued to Provincial Silviculturists. (Possibly a descriptive note might be added for each).
4. There should be one good library in each province. The Silviculturist should also have his own library with all Indian publications including selected working plans.
5. If the recommendation of the Empire Forestry Conference is acted on, that the Imperial Forest Institute should issue quarterly a publication on the lines of "Biological Abstracts", all provinces should procure a copy of this publication. The Central Silviculturist should then intimate to Provincial Silviculturists the titles of books and papers available in the Forest Research Institute Libraries, and invite attention to those items which he might consider of special interest to each, adding such notes as he might think useful. The Central Silviculturist should further consider a scheme whereby each province might deal with 2 or 3 periodicals with a view to this annotation, such scheme to be circulated to Provincial Silviculturists for criticism.

6. The lists printed in the Central Silviculturist's paper should be revised* and published for circulation (*vide infra*).

PAPER (*i*).

Contributed by

H. G. CHAMPION, *Silviculturist, Forest Research Institute.*

The Silviculturist's real sphere of action is the forest (including potential forest land), but under modern conditions, he will find himself left badly behind if he relies entirely on his own experience and his own investigations. Even within the limits of India and Burma, there are quite a number of us working on similar subjects, each getting results, let it be hoped, which are of more or less value to the rest, saving them labour and time in unnecessary trials and repetitions.

Our general organisation should provide for early circulation of knowledge acquired in any one quarter, and in so far as that fails, we have to rely on published information.

The chief publications concerned directly or indirectly with Silvicultural matters are listed below.* They have been classified for convenience under a number of headings, and symbols have been affixed to differentiate with regard to importance as follows:—

**Books which every silvicultural library should possess.

*Books which (or some of which, in the case of provincial publications) are necessary in some provinces but not in others.

†Books which are selected as the more important of the remainder

LIST 1.—*Indian Forest Publications.*

**1. *Indian Forester.*
*2. *Provincial Administration and Research Reports.*
**3. *Progress Report on Forest Research in India.*
**4. *Forest Institute Bulletins, Forest Records, etc.*
*5. *Provincial Bulletins, etc.*
*6. *Inspection Reports of the Inspector General of Forests, etc.*
*7. *Working Plans.*

LIST 2.—*Indian Publications not primarily on Forestry.*

1. *Agricultural Journal of India.*
2. *Journal of the Bombay Natural History Society.*
3. *Journal of the Indian Botanical Society.*
4. *Annual Reports of the Meteorological Department.*
5. *Agricultural Research Institute Bulletins and Memoirs.*
6. *Journal of the Asiatic Society of Bengal.*

LIST 3.—*Forest Publications of Countries adjacent to India.*

† 1. *Tectona* (Java).
2. *Philippine Journal of Science.*
† 3. *Malayan Forest Records.*

LIST 4.—*Asiatic Publications not primarily on Forestry.*

† 1. *Tropical Agriculturist.*
† 2. *Malayan Agricultural Journal.*

LIST 5.—*Books on Indian Forestry.*

**1. *Silviculture of Indian Trees*, 3 Vols. . .	R. S. Troup . . .	1921
**2. *Forest Pocket Book*	S. H. Howard . .	1927
**3. *Practical Forest Management* . . .	C. G. Trevor and E. A. Smythies . . .	1923
**4. *Note on the Preparation of Forest Working Plans in India*	W. E. D'Arcy, revised by A. M. F. Caccia .	1918

*The lists are here reprodnced after revision.

LIST 5.—*Books on Indian Forestry*—contd.

**5.	*A Concise Manual of Silviculture* . .	H. Jackson . . .	1906
**6.	*A Note on some European Silvicultural Systems, etc.*	R. S. Troup . . .	1916
**7.	*The Methods of Preparing Volume and Money Yield Tables for Teak Woods, and Volume and Form Factor Tables for Teak Trees,* from data collected in the Nilambur Teak plantations of the South Malabar Division, Madras, South India.	R. Bourne . . .	1916-19
**8.	*Manual of Forest Mensuration* . . .	Revised by C. E. Simmons	1926
**9.	*Tables showing the Cubic Contents of Round and Squared timber, etc.*	L. Mercer . . .	1901
**10.	*Code for the Collection and Tabulation of Statistical Data*	S. H. Howard . .	1921
**11.	*Nursery Notes for Bengal*		1926

LIST 6.—*Selected Indian Forest Records, etc.*

*1. *Note on Oecology of Sal, Parts I—III*, by R. S. Hole, Ind. For Rec., Vol. V, Part IV.

*2. *Note on the Afforestation of Ravine lands in the Etawah Division*, by E. A. Smythies, Ind. For. Rec., Vol. VII, Part VIII, 1920.

**3. *Notes on Artificial Regeneration in Bengal*, by Messrs. A. K. Glasson, P. T. Russell, E. O. Shebbeare and L. E. S. Teague, Ind. For. Rec., Vol. VIII, Part IV, 1922.

*4. *A Sal Yield Table for the United Provinces*, by E. A. Smythies and S. H. Howard, Ind. For. Rec., Vol. X, Part III, 1923.

*5. *General Volume Tables for Sal*, by S. H. Howard, Ind. For. Rec., Vol. X, Part VI, 1924.

**6. *Regeneration with the assistance of Taungya in Burma*, by H. R. Blanford, Vol. XI, Part III, 1925.

*7. *Volume and Outturn Tables for Sal*, by S. H. Howard, Ind. For. Rec., Vol. XII, Part I, 1925.

*8. *Yield Table for Clear-felled Sal coppice*, by S. H. Howard, Ind. For. Rec., Vol. XII, Part IV, 1926.

*9. *Yield and Volume Tables for Chir*, by S. H. Howard, Ind. For. Rec., Vol. XII, Part V, 1926.

*10. *Yield and Volume Tables for Deodar*, by S. H. Howard, Ind. For. Rec., Vol. XII, Part VI, 1926.

**11. *Glossary of Technical Terms for Use in Indian Forestry*, by A. M. F. Caccia, Forest Bulletin 4, 1911.

**12. *Note on Weights of Seeds*, by S. H. Howard, revised by H. G. Champion, Forest Bulletin 41, 1928.

*13. *Rate of Growth of Bengal Sal*, by S. H. Howard, Forest Bulletin 46.

**14. *Classification of Thinnings*, by S. H. Howard, Forest Bulletin 52.

*15. *Preliminary Yield Table for Dalbergia Sissoo*, by S. H. Howard, Forest Bulletin 62.

*16. *Pinus longifolia*, by R. S. Troup, Ind. For. Mem., Vol. I, Part I, 1916.

LIST 7.—*Forest Floras.*

(Numbers 2, 3, and 16 are very out-of-date.)

1.	*A Forest Flora of the Andaman Islands* . . .	Andamans .	C. E. Parkinson . .	1923
2.	*Plants of the Assam and Khasia Hills* . . .	Assam . .	U. N. Kanjilal . .	1915
3.	*Trees of Eastern Bengal and Assam*	,, .	E. M. Coventry . .	1908
4.	*Trees Shrubs and large Climbers of Darjeeling Distriot* (Annotated List)	Bengal .	J. S. Gamble . . .	1896
5.	*List of Forest Trees of the Duars and Terai* . .	,, .	E. O. Shebbeare . .	1919

List 7.—*Forest Floras*—contd.

6. *List of Plants of the Chittagong Collectorate and Hill Tracts*	Bengal	R. L. Heinig	1925
7. *Trees, Shrubs and Woody Climbers of Bombay Presidency and Sind*	Bombay	W. A. Talbot	1909
8. *Forest Trees of North Malabar*	,,	F. Foulkes	1915
9. *List of Trees, Shrubs and principal Climbers in Burma*	Burma	A. Rodger	1921
10. *Forest Flora of British Burma*	,,	Kurz	1877
11. *List of Trees, etc., of the Southern Circle, C. P.*	Central Provinces	H. H. Haines	1916
12. *Forest Flora of Chota Nagpur*	,,	H. H. Haines	1910
13. *Descriptive List of the Trees, Shrubs, Climbers, etc., of the North and Berar Circles, Central Provinces*	,,	D. O. Witt	1916
**14. *Indian Trees*	India	D. Brandis	1906
**15. *A Manual of Indian Timbers*	,,	J. S. Gamble	1922
16. *Vernacular List of Trees, Shrubs and Woody Climbers of Madras Presidency*	Madras	A. W. Lushington	1915
17. *Forest Flora of the Punjab with Hazara and Delhi*	Punjab	R. N. Parker	1918
18. *The Forest Trees of Travancore*	Travancore	T. F. Bourdillon	1908
19. *Forest Flora of the School Circle*	United Provinces.	U. N. Kanjilal	1928
20. *Descriptive List of Trees and Shrubs between the Ganges and the Sarda Rivers*	,,	A. E. Osmaston	1922
21. *Forest Flora of Kumaon*	Kumaon	A. E. Osmaston	1927

List 8.—*General Floras.*

1. *Bengal Plants*	Bengal	D. Prain	1903
2. *The Botany of Bihar and Orissa*	Bihar and Orissa.	H. H. Haines	1925
3. *Flora of Bombay*	Bombay	T. Cooke	1903-8
4. *Flora of the Malay Peninsula*	Burma	H. N. Ridley	1922-25
5. *Flore Général de l'Indo-Chine*	,,	Leconte	1907
6. *Flora of British India, I-VII*	India	J. D. Hooker	1875-97
7. *Flora of Madras Presidency*	Madras	J. S. Gamble	1915-25
8. *Flora of the Nilgiri and Pulney Hill Tops*	,,	P. F. Fyson	1915
9. *Flora Simlensis*	Punjab	H. Collett	1902
10. *Flowering Plants of Travancore*	Travancore	M. Rama Rao	1914
11. *Flora of the Upper Gangetic Plain*	United Provinces.	J. E. Duthie	1905

List 9.—*Forest Periodicals in English.*

**1. *Empire Forestry Journal.*
2. *Transactions of the Royal Scottish Arboricultural Society.*
3. *Transactions of the English Arboricultural Society.*
**4. *Forestry* (Oxford).
5. *Proceedings of the Society of American Foresters.*
6. *Quarterly Journal of Forestry* (London).
**7. *Journal of Forestry* (Washington).
8. *American Forest and Forest Life.*
9. *Canadian Forest and Outdoors.*
10. *Australian Journal of Forestry.*
**11. *Oxford Forest Memoirs.*

List 10.—*Non-forestry Periodicals in English.*

†1. *Journal of Ecology* (London).
2. *Science Progress.*
3. *International Review of the Science and Practice of Agriculture.*
4. *Nature* (London).
5. *Ecology* (New York).
*6. *Biological Abstracts* (New York).

List 11.—*Forestry Periodicals in other languages.*

1. *Zeitschrift für Forst-und Jagdwesen* (Eberswalde, Prussia).
2. *Allegemeine Forst und Jagdzeitung* (Bavaria).
3. *Tharandter Forstliches Jahrbuch* (Tharandt).
4. *Forstwissenschaftliches Centralblatt* (Bavaria).
5. *Centralblatt fur das gesamte Forstwesen* (Vienna).
6. *Schweizerische Zeitschrift für Forstwesen.*
7. *Wiener Forstzeitung.*
†8. *Mitteilunge der Schweizerischen Centralanstalt für das forstliche Versuchswesen.*
†9. *Forstlicher Jahresbericht.*
†10. *Revue des Eaux et Forêts.*
11. *Journal Forestier Suisse.*
12. *Bulletin de la Société Forestière de Franche-Comté et Belfort.*
13. *Bulletin de la Société Centrale Forestière de Belgique.*

List 12.—*Important Reference Books on Forestry in English.*

**1. *Research Methods on the study of Forest Environment*	R. Zon and C. G. Bates	.	1922
**2. *Statistical methods in Forest Investigative work*	W. G. Wright	.	1925
3. *Statistical methods for Research Workers*	R. A. Fisher	.	1928
†4. *Research methods in Ecology*	F. E. Clements	.	1905
**5. *Aims and Methods in the Study of Vegetation*	Tansley and Chipp	.	1926
**6. *Practical Plant Ecology*	A. G. Tansley	.	1928

Research Methods.

Silviculture (General).

**7. *Manual of Forestry, Vol. II (Silviculture)*	W. Schlich	.	1904
**8. *The Practice of Silviculture* (New York)	R. C. Hawley	.	1929
**9. *Silvicultural Systems*	R. S. Troup	.	1928
**10. *Theory of Forest Types*	A. K. Cajander	.	1926

Regeneration.

**11. *Seeding and Planting*	J. W. Toumey	.	1916

LIST 12.—*Important Reference Books on Forestry in English*—contd.

	TENDING.		
**12.	*The Pruning of Trees and Shrubs* . .	W. Dallimore . .	1925
	INJURIES.		
**13.	*Range and Pasture Management* (New York)	A. W. Sampson . .	1923
14.	*Incendies en Forêt* (Forest Fires) . .	A. Jacquot . . .	1910
	CLIMATIC EFFECT, ETC.		
**15.	*Forests, Woods and trees in relation to Hygiene*	A. Henry . . .	1919
	MENSURATION.		
**16.	*Manual of Forestry, III* (Management and Mensuration)	W. Schlich . . .	1925
**17.	*Forest Mensuration*	H. H. Chapman . .	1921
	FINANCE.		
†18.	*Forest Valuation*	F. Roth . . .	1916
**19.	*Forest Valuation*	H. H. Chapman . .	1924
	MANAGEMENT.		
**20.	*Theory and Practice of Working Plans* (New York)	A. B. Recknagel . .	1927
	ORGANISATION.		
21.	*American Forest Regulation* . . .	T. S. Woolsey . .	1927
	CONNECTED SCIENCES.		
*22.	*Text-book of Botany* (Translation: 5th Edit.)	E. Strasburger . .	1921
**23.	*The Soil*	A. D. Hall . . .	1908
**24.	*Soil Conditions*	E. J. Russell . .	1917
*25.	*Soil Characteristics*	P. Emerson . . .	1925
26.	*An Outline of Plant Geography* . .	D. H. Campbell . .	1926
†27.	*Plant Succession*	F. E. Clements . .	1906
†28.	*Ecology of Plants* (Translation) . .	E. Warming . .	1909
†29.	*Plant Geography* (Translation) . . .	A. F. W. Schimper .	1923
**30.	*Plant Physiology* (English Translation) .	Jost	1907
**31.	*Geology of India*	D. N. Wadia . .	1926
**32.	*Outline of Genetics*	M. C. Coulter . .	1923
**33.	*Mendel's Principles of Heredity* . .	W. Bateson . . .	1909
34.	*Graphical and Mechanical Computation* .	J. Lipka . . .	1923
35.	*Elements of Statistics*	A. L. Bowley . .	1926
36.	*An Introduction to the Theory of Statistics*	G. U. Yule . . .	1927

LIST 13.—*Important Reference Books on Forestry in other languages.*

†1.	*Handbuch der Forstwissenschaft, I-IV* .	H. Weber . . .	1926
2.	*Waldbau*	R. Bühler . . .	1918
3.	*Die pflanzengeographischen Grundlagen des Waldbaus*	K. Rubner . . .	1925
4.	*Über Düngung im forstlichen Betriebe* .	M. Helbig . . .	1906
†5.	*Restauration et Conservation des Terrains en Montagne*	Daubrée . . .	1911
6.	*Handbuch des deutschen Dunenbaues* .	P. Gerhardt . . .	1900
†7.	*Economie Forestière*	G. Huffel . . .	1920
8.	*Lehrbuch der Holzmesskunde* . . .	U. Müller . . .	1923
†9.	*Leitfaden der Holzmesskunde* . . .	A. Schwappach . .	1923

LIST 13.—*Important Reference Books on Forestry in other languages*—contd.

**10.	*Ertragstafeln der wichtigeren Holzarten*	A. Schwappach	1923
11.	*Lehrbuch der Waldwertrechnung und Forststatik*	Dr. Max Endres	1923
12.	*Die Forstliche Statik*	H. Martin	1915
13.	*Theorie der Forstlichen Oekonomik*	R. Godberson	1926
†14.	*L'aménagement des Forêts, etc.*	H. E. Biolley	1920
†15.	*Die Forsteinrichtung*	F. Judeich	1923
16.	*Praktische Forsteinrichtung*	L. Huínagel	1921
†17.	*Illustriertes Forstwörterbuch*	A. Schwappach	1924

LIST 14.—*Dictionaries, Glossaries, etc.*

1.	*Deutsch-englishes Forstwörterbuch*	K. Philipp	1900
2.	*Vocabulaire Forestier Francais—Allemand—Anglais.*	Gerschel & Fisher	1911
3.	*Muret-Sanders Enzyklopedishes Wörterbuch*	M Sanders	1910
4.	*Thesaurus of English Words and Phrases*	P. M. Roget	1920
5.	*The King's English*	H. W. and F. C. Fowler	1924
**6.	*A Glossary of Technical Terms for use in Indian Forestry*	C. G. Trevor	1929
**7.	*Glossary of the Botanic Terms used in describing flowering plants*	R. L. Heinig	1898
8.	*Times Atlas*		

The unmarked books should be accessible on occasion to all workers; they should of course be among the far more comprehensive central library essential at the Research Institute, but being reference works many of them will not be available for loan outside. It is therefore advisable that there should be second copies with the Central Silviculturist so that one or other can be lent when required. With the foreign periodicals and less used works, this duplication is not necessary. and it has been arranged that these are acquired and retained by the Silviculturist, instead of by the central library.

Some arrangement is desirable by which the attention of Provincial Silviculturists may be definitely directed to important new books likely to be of use to them, though actually these are ordinarily noticed in the " Indian Forester ". Further, provincial workers should be informed of additions to the Research Institute libraries in the subjects primarily concerning them. It is suggested that the Central Silviculturist circulates such a list annually with brief notes on each.

An up-to-date catalogue of the libraries at the Central Institute is much needed, and should be in the hands of all research officers in the provinces. A supplementary list of books added should be published annually.

PAPER (*ii*)

Contributed by

S. H. HOWARD, *United Provinces.*

The libraries to be dealt with are the Central Library at the Dehra Dun Forest Research Institute, the Imperial Silviculturist's library, and the libraries of the Provincial Silviculturists. Incidentally there are also Divisional Officer's libraries and in some provinces a Chief Conservator's or Conservator's library.

I do not profess to have solved this problem and I put up these suggestions merely as a basis for discussion. I have put no resolution and I doubt if one is necessary.

The first point is of what should the Central Library, or rather its Forestry Section, and the Imperial Silviculturist's library consist. When I came to Dehra Dun many of the books in the Central Library catalogue were taken out permanently by the Silviculturist and were in fact in his library, though in theory he had very little of his own. I did not like this arrangement and sent all the Central Library books back to the Central Library. But I soon found that books were not then available when the Silviculturist wanted them. The objection to two complete libraries was expense. But in practice I found that at least two copies were needed of all the more important books and there seemed no reason why one should not be kept in the Silviculturist's library. I therefore separated again and began to build up a separate Silviculturist's library.

I suggest now that probably the best solution is to have two entirely separate libraries—the central library for students, instructors and the department generally, and the Silviculturist's library for him in particular. He will have in it books covering all Forestry proper (except utilisation), *viz.*, General, Silviculture, Injuries (with protection), Economics, Mensuration, Forest Finance, Organisation and Administration.

He should make his library as complete as possible. Whenever, however, he wishes to order a book, he should consult the Central Library as to whether a copy is needed there as well. If it is, two copies (or more) would be bought. If it is thought unnecessary, only one copy should be bought and it should be kept in the Silviculturist's library. In the main catalogue of the Institute it can be noted as in the Silviculturist's library and, when necessary, should be issued to any one who wishes to read it for a definite short period. If it is found to be always out it will be a good reason for buying a second copy for the Central Library. It would facilitate matters if the classification in both libraries were the same.

There can I think be no connection between the Provincial Silviculturist's libraries and the Central Institute libraries except that Provincial Silviculturists should be permitted to borrow under definite rules. The Province must decide themselves how complete they wish their library to be, but it seems unnecessary to have both a Silviculturist's and a Chief Conservator's library. One really good Provincial Library should be sufficient, and if the silviculturist's headquarters are at the same place as the Chief Conservator's and Working Plan offices, it removes all difficulties except that the Utilisation head must also be included. Here again it is only a question of classification and it would be preferable if the libraries were all classified on the same system. In the system of classification which is to be put to the conference, there is a vacant head left for Utilisation under which all those books can be classified though I have not worked out that head.

Provincial libraries should have a proper classified list available for Divisional offices to whom books should be freely issued.

Divisional libraries I hardly propose to touch. As they are not very much used they should be restricted as far as possible. They should contain a complete set of Indian publications but outside that need have little except tried and standard text books in English.

Report of Debate.

(Extract.)

Chairman: I should like to say a few words about what was decided in Australia regarding the Forest Bureau. The Empire Forestry Conference have been discussing about the Forestry Bureau in their last two conferences, and at the last conference, it was decided to ask Professor Troup to start such a bureau, the functions of the bureau being to record and publish notes on forest literature, and to provide translations or abstracts of any particular work to any Forest Officer on request, and Professor Troup was asked to give an estimate of the cost of this, and it was estimated to amount ultimately to something like £ 2,500 per annum. And the Conference agreed that such an institution should be set up, provided the various parts of the

Empire would subscribe the funds necessary, and in due course India and the various provinces of India and Burma will be asked to subscribe their share of the cost of this bureau, and I think we shall all derive a considerable amount of benefit from it. At present there is quite a lot of literature in languages which certainly no body in Dehra can read, and a lot of publications in Norwegian, Finnish, Russian, etc., which are merely abstracted in English and German, and it can be of very great advantage if we can (if anybody is particularly interested in any particular article) obtain a complete translation from Oxford. So that is the position as regards the Imperial Forestry Bureau.

I have to refer to the reference of the Committee to notice of books published, and I think an abstract might very well be published annually in the "Indian Forester" so that a Divisional Officer can see what is going on in forest literature in the world, and so that he can be in a position, if he thought a book interesting and wanted it, to obtain such a book from the central library here.

ITEM 4.

INTERCHANGE OF WORKING PLANS AND OTHER PUBLICATIONS.

A paper was presented by Mr. Trevor (Vice-President, Forest Research Institute) and shorter notes by Messrs. Hewett (Burma), Homfray (Bengal), Newman (Bombay), Rowbotham (Assam), Sher Singh (Kashmir), Shirley (Burma), Smythies (United Provinces) and Vahid (Central Provinces), and the Silvicultural Sub-Committee, Bihar and Orissa.

Mr. Trevor opened the debate (*cf. infra*) summarising the opinions of the provinces as expressed in their notes. He shewed that it was inadvisable to reopen the question of free distribution of working plans and that general reciprocation at a nominal figure of Rs. 2/- should be recommended. There was some discussion as to whether maps should be included, custom varying with the province concerned, and as to the number of copies of each plan to be printed.

It was decided that no action was necessary at present as regards prices of publications other than working plans.

The following resolution was proposed by Mr. Trevor and seconded by Mr. Garland (Bombay), and passed:

Resolution 4.

Resolved *that provinces be asked to charge a nominal price of Rs. 2/- per copy for Working Plans (including such printed maps as are usually included with them) supplied to the Inspector General of Forests, the Forest Research Institute and College, the provinces of India and Burma, the Forest Departments of Indian States, and professional foresters in other parts of the world applying for them.*

The number of copies to be printed should be decided by the Working Plans Branch.

Report of Debate.

(Extract.)

Mr. Trevor: You will be struck by the preposterous prices which various Provinces have demanded for official publications, especially Working Plans. There is an item of Jhansi Division put at Rs. 49/9/- which seems a very large price to pay. Mr. Davis's plan for one of the Bombay Divisions is priced at Rs. 161/1/- [This a mistake: it is actually Rs. 81/-].

Well, gentlemen, these prices are perfectly ridiculous. Burma has agreed with the United Provinces, the Punjab and the Central Provinces to reciprocate in the matter of prices, and to charge a nominal figure of Rs. 2/-, which is perfectly reasonable as Working Plans are only issued for departmental purposes. Most provinces have recorded their views, and I think the best policy to pursue is not to reopen the question of free distribution of Working Plans, but to continue the arrangements which have already been brought into force by many provinces, and to try to obtain a general agreement that all provinces will charge Rs. 2/- for their Working Plans.

The Chief Conservator of Forests, U. P., was not anxious to reopen the question of free exchange of working plans as it had already been decided by the Government. But I think as an agreement has already been arrived at between some Provinces, we may all of us agree to reciprocate, and price all our working plans at Rs. 2/- each, *i.e.*, if any Forest Institute or any Province requires a working plan, they will be charged only Rs. 2/- per plan.

* * * *

Before I sit down I must deal with other publications apart from the Working Plans, but they do not matter very much and they are generally fairly reasonably priced. I think the cost of the Annual Report is something like Rs. 5/- which is not much to ask provinces to pay, and I think we should be well advised to leave the question of other publications as it stands

at present. They are reasonably priced and there is no case to go up to Government for exemption of such publications from the general orders of the Government, that if provinces want publications from another province they have to pay for them. I should be very glad to hear any gentleman who may wish to speak on the subject. Perhaps Mr. Smythies may like to talk about it.

Mr. Smythies: We actually charge Rs. 2/8/- for our coloured maps but that does not matter very much.

Chairman: I should say Rs. 2/- without the map, and if anybody wants a map he should pay the Rs. 2/8/- extra.

Mr. Smythies: If the Conference wants to have the maps included, I don't think there will be any loss to anybody. The ordinary maps have certainly been included in the price.

Mr. Harlow: The Central Provinces follow exactly the same system as is followed in the United Provinces. We get our maps printed in the Forest Office and then those required by the staff are coloured in the working plans office, and if we have to colour all the maps that are sent out to the various provinces. it will involve lot of extra staff. The printing of ordinary maps is not going to cost us more, but the coloured maps make a very great difference. and we will have to make it a rule that if anybody wants coloured maps, he will have to pay for them.

Chairman: The position is that in some provinces a working plan map is issued with the publication, in other Provinces like the United Provinces and the Central Provinces, the Working Plan map is not issued with the publication. A map is prepared for their local use. but it is not issued as part of the publication. I think the best thing is to leave them aside. If the map is published with the plan it will be issued, but if anybody wishes a map which is not published with the plan, he will have to pay extra for it.

Mr. Blanford: May I suggest a wording '*Working Plans, including such printed maps as are ordinarily issued with them*'?

ITEM 5.

REVISION OF THE GLOSSARY OF TECHNICAL TERMS.

A complete revision of the current glossary was made by Mr. Trevor (Vice-President, Forest Research Institute).

Other addenda and corrigenda were suggested by Messrs. E. A. Garland (Bombay), C. K. Homfray (Bengal), D. G. B. Manning, (Burma), Sher Singh (Kashmir), G. S. Shirley (Burma) and the Central Silviculturist, and notes were submitted by Assam, Bihar and Orissa, the Central Provinces and the United Provinces.

A Committee, consisting of Messrs. Trevor (Chairman), Blanford (Burma), Kitchingman (Punjab), Minchin (Madras) and Smythies (United Provinces), was appointed to examine the various proposals, and report to the Conference.

The Committee made minor amendments of Mr. Trevor's draft new Glossary and reported to the Conference recommending the acceptance and publication of the draft glossary so amended. There was no debate, and a resolution was proposed by Mr. Trevor and seconded by Mr. Minchin, and passed by the Conference.

RESOLUTION 5.

RESOLVED *that the Conference generally endorses the publication of the new Glossary* †*and recommends its use in all technical publications.*

† This is being published se

ITEM 6.

PARTIAL STANDARDISATION OF EXPERIMENTAL RESEARCH METHODS.

A paper was presented by the Central Silviculturist, *vide* p. 44.

Notes were received from Assam, Bihar and Orissa, Burma, the Central Provinces and the United Provinces.

In Committee (Experimental and Statistical Committee), the Central Silviculturist summarised the proposals received, pointing out that several important points incorporated in his paper had been discussed with the Silviculturists of Burma and the United Provinces.

The report of the committee was as follows:—

Report of Committee.

The Committee discussed this question with reference to the Central Silviculturist's paper, and is of opinion that a general account more or less on the lines of this paper would be helpful, and should be compiled by the Central Silviculturist incorporating the suggestions which follow.

Scale of experiment: There is difference of opinion as to the scale which should be recommended for Stage I especially under the first two subjects, and it should be made more clear that the figures are only suggested and not prescribed. It should also be brought out that the Divisional Stage (Stage III) should be more definitely referred to as such, since the distinction tends to be sharp and important. The danger of Indicator plots ceasing to be typical of the experimental plot should be stressed and provided against.

Office Procedure: It is recommended that any forms adopted should be numbered serially throughout. The forms printed in the paper were submitted for consideration to a Sub-Committee consisting of Messrs. Champion (Chairman), Chaturvedi, Osmaston and Shirley. Some improvements are recommended by this Sub-Committee, but as these refer to details only it is not necessary to describe them here. The Sub-Committee was also asked to find a substitute for the word "recruitment" used in the paper, but was unable to do so, and suggested that "recruitment" might stand.

Natural Regeneration: The table of stages of regeneration was discussed and standards accepted for the 4 species specifically referred to it. It should be brought out that these are nothing more than convenient stages for purposes of reference, the term establishment being capable of many interpretations. The Committee agreed with the Central Silviculturist's proposal to recommend the check by the squares method as the best when practicable, his selective counting method replacing it when more convenient. Opinion was divided as to how much of the described procedure should be standardised and prescribed. The Central Silviculturist stressed his opinion that in experimental work, it is for the most part only possible to make recommendations and suggestions, to be followed as far as possible but not to the exclusion of measures better suited to the individual investigation in the opinion of the officer doing the work.

It is therefore recommended that the Central Silviculturist be asked to publish a manual of Experimental Research on these lines.

In debate, the only matter that provided further discussion was the attempt to find an acceptable term for use in place of 'recruitment' (already preoccupied in the Glossary) for the *first stage of seedling regeneration*; "primary" and "initial" were suggested, but no decision was reached. The report of the Committee was accepted by the Conference, a resolution to that effect being proposed by Mr. Harlow (Central Provinces) and seconded by Mr. Osmaston (Bihar and Orissa).

RESOLUTION 6.

RESOLVED *that the report* of the Committee be accepted.*

* [The report is printed above.]

PAPER

Contributed by

H. G. CHAMPION, *Silviculturist, Forest Research Institute.*

Research work ought never to be hampered by compulsory adherence to any prescribed methods either of investigation or of recording. This dictum, which cannot seriously be disputed, does not however prevent the research worker from receiving considerable aid from the results of his own experience and that of others, as to the simplest and most expeditious methods of dealing with much of his routine work and for first trials on new lines. This is particularly the case where the said research worker is new to his work as must frequently be the case with silvicultural investigations in India.

The greater part of our statistical research, which of course lends itself far better than the more definitely experimental subjects, to standardised procedure and recording, has been thus provided for with results which will probably be generally admitted as satisfactory; the one danger is that the methods may become stereotyped whereas they ought to be improved as improvements become feasible. There is a feeling that it would be helpful if the best methods for routine experimental work were threshed out and described, if not for universal and prescribed use, at least as a basis for use subject to improvement in the individual case.

A general study of the subject has been made by the present writer and a note (unpublished) written, of which the following pages are more or less summarised abstracts. A certain number of forms are proposed for adoption and are reproduced at the end. The first part is general, and the second deals with application of the general principles to natural and artificial regeneration investigations.

A. GENERAL.

1.—*The Scheme for an Investigation.*

The first essential is a clearly defined object as simple as possible. The titles of some of the older experiments are such as to render any useful result an impossibility. Actual examples are:—

> "To study natural and artificial regeneration of *sal*, *haldu*, etc."
>
> "To ascertain the best method of afforesting denuded areas of different types."

The simpler the problem, the more likelihood of a definite result, a clear answer to the question put to the forest, and often too, the shorter the time required to get it. Conversely, the wider the scope of the investigation, or the more involved the question to which an answer is sought, the less likely is a clear answer ever to be obtained. The ideal to aim at is to frame the investigation in such a form that the answer is simply *yes* or *no* without provisos (or as unimportant ones as can ever be hoped for in biological research).

A careful analysis of the factors involved is next required.

Thus failure to regenerate may be due to a long series of unfavourable factors such as:—

(*i*) Inadequate seed supply,
(*ii*) Low germinative power,
(*iii*) Destruction of seed by animals,
(*iv*) Unsuitable soil conditions,
(*v*) Unsuitable cover conditions, and
(*vi*) Unsuitable climatic conditions.

The next stage is to eliminate those factors, the influence of which is relatively so small as to be of little importance. This may often necessitate a little preliminary work, though the required evidence is usually available to direct observation in the forest. Another set of factors may exert an important effect though they cannot be altered, *e.g.*, aspect or quality of locality,

but it is none the less important to bear in mind their effect throughout the course of the investigation, keeping them as constant as conditions allow.

There is another method of eliminating the effect of variables, which is very useful for the minor ones and is sometimes permissible for the major, and that is by averaging or cancelling out.

For an example, we may refer to the effect of the aspect of the individual channel on the healing over of resin channels. A preliminary investigation showed that this effect, if any, was small, and all aspects being roughly equally represented, in examining the effects of other factors, it was justifiable to ignore it. On the other hand in determining the actual effect of aspect of channel, since locality aspect exerts a much larger influence, it is essential to examine separately the data for each locality aspect.

Obtaining suitable experimental plots with identical soil conditions is commonly a matter of great difficulty, and even with the greatest care, inequalities are liable to make themselves apparent later, possibly rendering comparison uncertain or impossible. The only remedy for this is repetition, and most experiments which are worth doing, are worth duplicating, and worth duplicating at the start without waiting till results have shown yet once again this inherent defect of the single experiment.

Another set of factors which must always be watched are time factors. Thus a sowing of a given species may be made on a given date one year and be a complete success, but may be repeated on the same date the next year and fail completely owing to different meteorological conditions prevalent during the two years; sowings may appear better than transplanting in one year and less satisfactory in the second year. Similarly for regeneration fellings and subsidiary operations depending for success on the occurrence of a seed year and satisfactory germination conditions. Similarly again, the date and moisture conditions at the time of burning a forest clearing for sowings and plantings will make all the difference between success and failure without any other complicating factors. *It is thus ordinarily not permissible to lay out part of a series of comparative experiments one year and the rest the next.*

II.—*Scale of Experiment.*

The scale on which an investigation should be made varies within wide limits, though always subject to one common proviso, which is that the result obtained from the plants or area under investigation should be applicable to any larger scale *as far as the silviculture is concerned*. To exemplify from extremes, the possibility of growing a species *A.b*, in the open from root and shoot pruned transplants of a given size put out at a given season, can be tested on 100 plants quite satisfactorily if soil conditions are uniform, or with a repetition of 100 for each soil type if the soil varies. If one puts them out with 6′ × 6′ spacing the area required is one-twelfth to one-third of an acre. Testing strip regeneration with 60′ strips and 120′ intervals requires a strip long enough to give all the conditions of a strip as opposed to a gap, and the ends ought to be excluded as they are affected by the unfelled trees blocking them. Hence a width of (60 + 120 + 120)′ = 300′, and a length of say 120 + 60 + 60 = 240′ is required, and the area will be over 1½ acre without any allowance for soil inequalities or repetitions, so that 5 acres is practically the minimum for such experiments.

Cattle and game damage should commonly be excluded in the experimental stage by adequate fencing: even if grazing is being investigated as a factor for success instead of destruction, one should try to have it controlled in time and amount instead of leaving it to chance.

The scale of an experiment must also be largely influenced by the stage reached in the investigation. The considerations above have been on the assumption that it is a new investigation probably based on a hypothesis formed as a result of direct observation in the forest. At this Stage I, it should be tried on the smallest scale compatible with the prospect of a dependable result as exemplified at the beginning of this section. Time, space and money ought never to be wasted in going beyond these limits until success has been obtained within them. One would like to go further and say these limits should be adhered to until success can be guaranteed within them, *i.e.*, until

the experiment has been successfully repeated, but in practice this is not always possible, however advisable, and the advance is made to Stage II, which may be called the " practical " scale and will be about 5—10 times the scale of Stage I. For plantation experiments an acre should be taken with 2 or 3 repetitions if possible. For regeneration experiments, depending on the type, 10 acres might be the minimum and 25 the average. Stage II ought to be done whenever possible by a research officer (or at least closely watched by him) particularly if the technique is at all unusual or critical, but in simple or clear cases may be taken over by the executive. The research officer will usually find he can effect improvements during Stage II and a fair idea of costs can be obtained. Stage II in turn successfully disposed of, there should be no need for further experimental work; the research officer withdraws, and the measure is suitable for a working plan prescription.*

Reverting to Stage I, experience has shown that there are considerable difficulties in following developments over relatively large areas in which the individual plants cannot be measured or counted. This is particularly the case with natural regeneration experimental plots. The difficulty is met by the creation and maintenance of smaller plots at present termed " Observation " or " Counting " Plots, better referred to as " *Indicator Plots* " (I. P.), within the Experimental Plots and of such size that the progress of each plant can be followed, either individually or in the aggregate. Such plots may be one or more in number according to the range in conditions, and may be located at random or in selected spots as considered best in each case. Even under apparently uniform conditions one would like two indicator plots, each to act as a check on the other, and to provide against any accidental happening spoiling one of them for the end it should serve, but in view of the time required for their inspection, it is not always possible to lay out more than one. When, as sometimes occurs, one requires to keep individual plants under observation, the I. P. is very convenient for the purpose; each seedling (or selected seedlings) may be mapped or numbered and its individual history followed (U. P. practice), whilst frequently an enumeration by height and appearance classes will suffice (Burma practice). The former method is of course borrowed from the familiar quadrat of botanical ecologists and is discussed further below.

The area or number of plants recommended for Stages I and II for the chief types of experiment are as follows. it being understood that each different type or quality of locality must usually be dealt with separately.

—	Stage I.	Stage II.
1. Afforestation or artificial regeneration.	1 acre . . .	5 to 10 acres.
2. Natural regeneration . . .	5 acres . .	25 acres.
3. Detailed artificial regeneration .	100 plants or patches: 500 running feet for line sowings	1 acre (same as entry 1, Stage I.)
4. Single measurements for analysis and percentage calculations (stem analysis, inheritance of defects, etc).	100-200 plants . .	Not required.
5. Single repeated observations (such as seasonal height growth).	10 plants . .	Not required.
6. Thinning, planting-space, etc. .	60 plants at end of experiment.	4-6 repetitions.
7. Nursery experiments . . .	3-5 beds in different parts of the nursery.	Repetition suffices.

* The views expressed in this paragraph will be found to agree in the main with what has been written in the U. P. Forest Pocket Book, q. v. p. 2.

III.—*Location of the Experiment.*

The first essential is ready accessibility. Unless conditions absolutely prohibit it, plots should be easily and quickly accessible at all seasons by rail and road. It is sound policy to concentrate as many plots in one range or division as possible, every care being taken at the start that the conditions there prevailing are reasonably representative of the whole area to which it is desired to apply any deductions which may be made from results obtained in the plots.

The detailed situation should also be regulated by considerations likely to facilitate obtaining a definite conclusion. (1) Just as the range and division must be readily accessible to the main line of communications, so should the spot selected be handy to a rest house or frequented camping grounds. (2) As far as possible, experiments should be done where facilities such as labour and water supply are satisfactory. (3) Areas should be selected where such complications as grazing, lopping, grass cutting and burning can be excluded or controlled without undue difficulty. (4) To avoid possible uncertainties in drawing conclusions and to disarm adverse criticisms of conclusions drawn, the plot should whenever possible be a part of much larger area similar in all essential features. It is inadvisable to use as a plot the greater part of a small patch of one type situated like an island in a second type, even if the former is considered to be representative of a large area less conveniently situated. (5) Weight is added to the desirability of laying out the plot in as extensive and uniform an area as conveniently available by the possibility of an occasion arising later when an additional plot is required to investigate the influence of some factor of unforeseen importance. (6) In any case marginal effects must be avoided just as for crop increment plots, by maintaining a " surround " of requisite width. The actual width must be determined in each case by the object of the experiment and the actual circumstances, but it will usually be about the height of the surrounding forest. (7) Overlapping experiments are sometimes permissible, where a given area is suitable for two disconnected sets of observations.

IV.—*Methods of Measurement.*

The importance of having a clear cut issue has already been emphasized, and this will usually of itself indicate fairly definitely what numbers or dimensions should be recorded. In the large majority of cases it is desirable to record progress and results numerically, though in the past ocular records and estimates have predominated. The main advantages of doing so are that it helps towards elimination of personal factors, ensures absolute as opposed to comparative records, and gives continuity in following the changes in development by directing attention to the same factors at each inspection. In the case of measurements, the unit of measure, the closeness of the measurement and the zero point, have all to be decided in each case.

The unit should be so selected that no change will be required later on: thus a change from inches to feet in the course of a single experiment is to be avoided. If results are plotted graphically the duodecimal division of a foot is a nuisance. A change from diameters to girths or *vice versâ* is to be deprecated.

Much time is often wasted taking measurements with an accuracy far beyond the limit set by unavoidable experimental errors. It may be worth while recording the height to the nearest inch of each seedling in an observation plot when one wants to follow the history of the individual, but in a plot where a count is made, it might be made in 1″, 3″ or 6″ classes, or even whole foot classes. As a rule, by adopting the wider limits for a class nothing useful is lost and labour in averaging is saved. Thus, fractions of an inch are often uselessly recorded and much labour wasted in measuring and recording plants to inches only to group them into foot classes. It must also be decided beforehand how measurements are to be rounded off and a standard procedure followed.

The zero point for measurement may often be of considerable importance: if seasonal height growths are being recorded to the nearest inch, the ground level must obviously be fixed to be constant within an inch and a firm peg on

which to place the measuring staff is essential, and the point which shall be considered as the top decided and adhered to.

In many experiments, especially with regeneration problems, it is important to decide at the start how progress is to be recorded and measured. Definitions are often required but rarely formulated, thus an expression like " Established regeneration " must not be used without prior definition. and a definition of course may not include any reference to matters of opinion or doubt, as is the case with one which has been published for the expression quoted. Arbitrary definitions are quite permissible for convenience, and far preferable to any uncertainty as to meaning. Other expressions loosely used are ' density,' and " percentage success ", and general terms such as ' *good* ', ' *fair* ', *stout* ', ' *failure* ', used without reference to any standard, are capable of giving a lot of trouble when an experiment is handed on to a second research worker. In regeneration investigations again, it is highly advisable to settle beforehand what will constitute success: results have been seen worked up in such a way that a single overdense patch of advance regeneration in one corner of a plot is dealt with in such a way as to make it appear that the plot was as well regenerated as a second plot which had a similar number of plants of the same height evenly distributed over the whole plot.

Instruments.—It should be a general rule that the instruments used should be of as simple a type as permits of the desired degree of accuracy, and within limits, as few in number as possible. Experiments of a special nature may often require special instruments, but if the desired records can be made with those always available like a 2′ rule, a steel tape, a pair of callipers and a simple hypsometer, one should be content with these.

V.—*The Initiation of an Investigation.*

(*a*) *Demarcation.*—In the case of short term experiments, something less elaborate is permissible, but the majority of plots require demarcation more or less as already standardised for Permanent Sample Plots, *i.e.*, permanent corner posts, preferably numbered (Burma uses teak posts with numbers outlined in nails to good purpose), and a shallow trench from post to post. In some districts, small masonry pillars may be preferable to posts, but in either case, possible trouble later in locating pillar or post in grass and weeds should be remembered and provided against. Straight line boundaries will almost invariably be preferable, with simple square, rectangular or few sided polygonal outline. A durable wooden or enamel notice board on the nearest approach path is a great aid in finding a plot. It should carry the number of the plot and the date of initiation is a useful addition.

(*b*) *Initial work.*—This will usually consist in regularising the area, in eliminating some more or less controllable variables affecting it, as by fencing or burning; the surround of a plot will be similarly treated. In artificial regeneration work there will be soil preparation and sowing or planting, and here too, great care must be taken to keep everything as uniform as possible, above all in comparative experiments.

(*c*) *Controls.*—Many experiments require a control as already mentioned, *i.e.*, an adjoining area, or set of plants, to which the treatment under investigation is *not* applied. The whole value of the work may depend on the care exercised in the selection of the control so that it really does give a reliable standard for comparison, a zero point for measurement as it were. It must be demarcated and written up exactly as if it were itself a plot—as in fact it always should be.

(*d*) *Indicator Plots.*—The necessity for closer observation of Indicator Plots within an Experimental Plot has been mentioned, and the selection of these plots is the next matter to be dealt with. The object being to measure progress on the Indicator Plots as a sample of the whole Experimental Plot, the range of conditions over the latter must be examined and the average selected—special cases or extremes can also be selected in addition if information is required about them. This selection is not easy; the ideal procedure would be to select provisionally several sites before doing anything and then choose among them after the initial work—which may be a heavy felling

and concentrated exploitation and extraction—has been carried out, probably spoiling some sites for the purpose intended. The probable future development must be visualised and taken into consideration at the start, *e.g.*, in any form of gap regeneration fellings, general observation will previously have indicated in which parts of the gap to place the plots. Cases may also be encountered where the best procedure is to distribute several Indicator Plots absolutely at random.

Indicator Plots are to all intents and purposes what is termed a quadrat by plant ecologists, and useful suggestions can be obtained from their experience; much of their work is however done on smaller plants in more open formation and their whole study is commonly more intensive than the silviculturist's.

The best shape and size of the Indicator Plot when mapping and individual record is to be done, is found by practical experience to be about $5' \times 20'$. Two and a half feet is the maximum width which can be examined from the edges without trampling on the plot, and twenty feet is a convenient length giving a total area of 100 square feet. $5' \times 21{\cdot}78$ (say 21′ 9″) has the advantage of being an exact fraction of an acre (one-four-hundredth) and is perhaps preferable. In perhaps the majority of cases, particularly with more advanced regeneration, a larger plot like the Burma "counting plot" (a misleading name as more than counting is usually done), 1 chain square, will usually be preferable, the progress of individual plants being arranged for by marking a suitable series of typical samples in any convenient way. Such marking may be by tying on a metal label or by marking with a durable peg in the ground, and the position of the marked plants should be recorded on a map on squared paper; the weed growth will commonly determine what is feasible, and what is not. $60' \times 80'$ is very simple to lay out, the diagonal being 100′ and the area one-ninth of an acre.

Indicator Plots must also be adequately demarcated. For the larger counting plot, durable corner posts high enough to be visible above the weed growth and a shallow trench will suffice, but for the smaller type in which individual seedlings have to be located, metal corner pins projecting only 1″ or so out of the soil should mark the actual boundary along which tapes may be stretched, and 1′ or 2′ outwards along the diagonals the corner posts should be erected and ditches dug between these posts.

VI.—*Initial Records.*

Perhaps the chief reason for the failure of so many experiments initiated in the past to yield conclusive results, is the common inadequacy of the initial records. The present condition is apparent, but what was the plot like when first laid out? Usually there is only a brief description in comparative terms, the standard of comparison even if indicated, no longer available. Well begun may or may not be half done, but badly begun in this respect is better not done at all, for it only involves uncertainty and waste of effort later on. For comparative experiments, above all, an adequate record of initial condition is the first essential.

Each demarcated plot is given at the start a serial number in Arabic numerals, separately in each forest division. These numbers must never be changed. Subdivision is to be avoided whenever possible, but if it is accepted as necessary, a small letter should be suffixed to the number, *e.g.*, 2a, 2b. Indicator Plots should be given Roman numerals I, II, III,.....within each Experimental Plot. The number of an abandoned plot should *not* be given to a new plot.

A great help towards the maintenance of adequate records, is the use of standard forms suggesting the heads on which information may be required. The proposed forms are given on p. 58 *et seq.* A standard form has been in use for some years for experiments on natural regeneration. The appended Experimental Plot Form 2 is considered to combine the best features of the alternatives tried. A few points require attention, and the chief are :—

(*a*) The record must be complete in itself, references to working plans, other Experimental Plots, etc., not being permissible under entries 6, 7, and 10.

(*ii*) Entries must all be absolute, *i.e.*, 12 (*d*) should not be filled in as "good", without some definition or explanation of what is implied by the word. Numerical expression is always to be preferred, thus "of healthy appearance, 2′—4′ high, well distributed with an average spacing of approximately 6 feet" cannot be misunderstood.

(*iii*) Excessive detail should be avoided, notably under entry 10, Type of forest, and 12 (*c*) Weed growth.

(*iv*) The entry for the interval at which inspections are to be made has sometimes been excluded from the form, but it serves a useful purpose as an additional reminder of the precise object of the experiment, especially when the plot is handed over to a new investigator, and it facilitates maintenance of the programme of work.

(*v*) All entries must be filled up, even if only with the word *nil*. There is an inevitable tendency for the number of unfilled entries to increase steadily if any are allowed to be blank, and uncertainty can only result later as to whether the entry is really *nil*, unknown, or merely unrecorded.

(*vi*) Botanical names for trees and plants should be used in preference to vernacular names, but the latter can be used if definitely more convenient (*e.g.*, *ulla* instead of *Anthistiria gigantea*) after both have been given together in Form 2.

(*vii*) The last of the entries should be signed by the officer making them.

This Form 2 is the main record, but it requires some supplementing. A map is required showing the whereabouts of the plot in the forest (Form No. 1). This should be traced off the largest scale map in use locally, preferably 4″ = 1 mile, and should shew clearly the situation of the plot. A second large scale map of the plot itself (Form No. 1a) is also required shewing its shape, size and boundaries, the position of the Indicator Plots if any, and sometimes the position of seed trees and similar details. This should be of a size convenient for a foolscap page (rarely double), and on strong paper.

One other record usually made at the initiation of an experiment, is the list of numbers or measurements of the plants of the whole plot or its indicator plots. The nature of these figures will vary somewhat with the experiment, but Form 4 serves for simple cases of successive enumerations in classes, and as a summary for Form 3. Form 3 provides for records by individual plants, particularly with natural and artificial regeneration, and a third map on Form 3a (squared paper) will often be required for use in this connection, whether for the whole of a small experimental plot, or for an indicator plot. Form 3 itself makes provision for analysis of the measurements simple enough to be filled in at once in the field, but usually the Summary Form, No. 4, will be required. These forms and maps are collected in a standard cover with locality, experiment number, etc.

Abbreviations can be either very helpful or almost a curse. To allow of the former epithet, they should be limited in number and as suggestive as possible. This calls for a careful decision among the possibilities, thus *d* must not be *dead* or *dormant* or *divergent* as it is already standardised as meaning *dominated; dd, dor* and *dvg* are preferable suggestions. Some of the commonest requirements are provided for in Form 3. Frequencies often require to be noted, and for this it is best to adopt the abbreviations generally used by plant ecologists, which are:—

va = very abundant.	*o* = occasional.
a = abundant.	*r* = rare.
f = frequent.	*vr* = very rare.

[*l* = local, may be prefixed to any of the preceding.]

The foregoing paragraphs apply in the first place to an absolute investigation, and require some modification for sets of comparative plots. A Form 2 with its maps is required for the set as a whole, the record for each consti-

tuent experiment being written up just as for an absolute investigation, except that the general map and the entries of Form 2 which are common to all, are recorded in the set file. Comparison should find no place on the individual plot file, but only on the set file.

For nursery and garden experiments, Form 6 will be found useful, whilst germination tests are provided for in Form 5.

It remains to add that in many cases a photograph of a plot can convey a better idea of the initial condition than many pages of description. If conditions allow, it is desirable to take it from such a point that with the expected development, it should be possible to get a good view for further photographs from the same spot at later inspections, and it helps to include in the photo an easily recognisable post, stone, stump, tree or similar object.

VII.—*Expansion, Sub-division and Repetition of Experiments.*

Sub-division is—unless definitely provided for at the start—highly objectionable in the large majority of cases. The scale of the experiment necessary for the object in view has been decided at the start, and very good grounds indeed are required to justify a reduction. Sub-division has as an almost inevitable consequence a departure from the ever-to-be-desired simplicity of issue, and commonly leads on to losing sight altogether of the original question. There are cases of course in which sub-division is expected and provided for, *e.g.*, where two plots are identical except that one has two weedings or burnings and the other only one, but these are fundamentally comparative experiments better kept separate from the start as already shown. In those cases in which sub-division is held to be the best course in view of special circumstances, new files should be opened for each sub-division, and each should be considered and treated as a new (comparative) experiment. The original experimental plot number should be kept and a letter added—33a, 33b. *Repetition* is often found desirable but introduces no new problems. A repetition constitutes a new experiment with a new number but the same title as the old. Under the Remarks entry of Form 2 should be given a note emphasising any important differences between it and the experimental plot of which it is a repetition.

VIII.—*Maintenance of Records.*

The chief record is Form 2 (contd.), " Subsequent History " for both Experimental and Sample Plots, which carries on after the initial account in Form 2. In practice, the only difficulty in filling it in is to give enough but no extraneous information. The commonest failing is to include superfluous opinions as to what is likely to happen according to the writer, instructions or proposals for work to be done, and descriptions of matters which are quite outside the object of the experiment and in any case, totally out of place in this form. Many of these things may require to be written, but not in this place, and Form 2a must be written up with a single eye to the declared object and with maximum clarity and brevity.

Besides this, care should be taken to adhere rigidly to the same units and definitions as adopted for Form 2, and to define any new terms introduced, thus, if regeneration passes to the " sapling " stage, a definition of what is here meant by a sapling must be available.

All entries must be dated and signed. The signature has in the past often been omitted originally or in copying. When the file passes to the hands of a new investigator, it is of considerable value to know who was the author of each entry—every worker has his own little peculiarities, usually unrealised by himself, which may explain what would otherwise be obscure.

Further entries will be required in Form 3 and 4 (and perhaps the map 3a) for Experimental Plots, and in Form 6, 7 and 8 for garden experiments.

Some form of strong loose-leaf binder is accordingly necessary, of a type such that there is no danger of loss or misplacement of papers, and with a strong cover both as protection and to provide a good back for writing. It should be a rule that all records of measurements be recorded direct, not

copied but in original on the permanent file, though fairing out descriptive notes is permissible if not often preferable. In the case of comparative investigations, the entry in Form 2 (contd.) of the set file is a critical survey of the corresponding entries on Form 2 (contd.) and subsidiary forms of the several constituent plot files, combined with additional comparative field observations if any are apparent.

One matter remains for consideration in this section—provision for a periodic summary of progress and results. The need for this has frequently been felt particularly for long term regeneration experiments, and Form 2 (contd.) where such summaries have been put, is not appropriate, as is apparent from its title alone (" Subsequent History "). Form 2a meets this requirement. Such summaries are most usually advisable once annually between two periods of growth.

IX.—*Office Procedure.*

The records referred to in the preceding paragraphs for experimental and observational research are—

Form Number.*	Description.	Investigations for which maintained.
1	Situation Map . .	All E. P.'s and Miscellaneous experiments in the forest: some forest investigations.
1a	Plot Map . . .	All permanent plots unless Form 3a is more convenient.
2	Description of Plot .	All plots and investigations except those done in an Experimental Garden.
2 (contd.)	Subsequent History .	All experiments, except those in Experimental Gardens.
2a	Periodic Summary . .	Ditto ditto.
3	Record of measurements .	All investigations and experiments involving repeated measurement of individual plants.
3a	Tree Chart . . .	For plots and experiments when position of individual plants may require checking at re-measurement.
4	Summary of measurements and counts	For all experiments and investigation with repeated measurement or classification of plant (often as summary to Form 3).
5	Nursery and Garden Record.	Nursery bed and Experimental Garden work (replacing Form Nos. 2 and 2 contd.).
6	Nursery Summary . .	Nursery bed work (summarising Form No. 5).
7	Artificial Regeneration Summary.	Artificial regeneration in an Experimental Garden (summarising Form No. 5).
8	Germination Test Record.	Germination Tests.

A question which arises is as to what, if any, copies of the records should be made. There are some advantages in duplicating the records, keeping one file for field use and a fair copy for permanent record in the office; whether this is advisable or not, depends mainly on the staff, the facilities, and the experiment in question, but in any case, one file must be recognized as the original, and include all the original measurements. The chief advantage of a fair office copy is the possibility offered of trimming off from the field copy all superfluous details which will inevitably find their way in the account first written up: also of general editing. For short term experiments (continued 2—3 years at the most), the single field record is enough, but for longer investigations like most on natural regeneration, the field copy of Form 2 (contd.) should be periodically summarised in Form 2a.

This annual summarising is helpful in other ways. The majority of experiments are carried out in the forests, and the local forest officers like to be—and ought to be—kept informed of what is going on. It is easy to type an extra copy of Form 2a for the divisional forest officer concerned (as also for the Research Institute). It serves the further purpose of keeping attention

* It would really be better to renumber the forms serially throughout; [This was agreed on by the conference. Ed.]

directed to the primary object of the work; it is also suggestive for future work; and moreover, such summaries are usually wanted for purposes of Annual Reports.

X.—*Confirmation of Results.*

Under Section II above, the stages were considered by which procedure should pass through experiment to practice, and it was remarked that ideally, successful repetition of a concluded experiment should precede its wider application. Unfortunately time does not stand still, and one wants to make full use of discoveries at the earliest possible moment. This however does not alter the fact that intentional repetition serves a very useful purpose. Firstly meteorological conditions are never identical in two seasons, and in any one may by chance have been abnormally favourable or unfavourable for the experiment. Secondly, personal factors come in in selecting the time for operations, etc., and it requires to be shown that the result is independent of these. Finally, what is virtually a repetition of one completed experiment may serve as a check, and at the same time be made to yield additional information on other points. Silvicultural methods which have succeeded experimentally are often not nearly so successful when applied on a larger scale, and among the many possible causes is often the one that the experiment was carried out under conditions which are not, in actual fact, those existing for the big scale attempt. Had time and facilities allowed, simultaneous or successive repetitions might easily have shewn what to avoid. Repetition on Scale II serves the double purpose of confirming the results obtained from Scale I and at the same time partly bridges the big gap between Scale I and the hundred-fold practical application. All the new factors affecting divisional work are not introduced, but at least some are.

B. Specific Problems.

1.—*Natural Regeneration.*

It is with natural regeneration of forests that the investigator finds himself confronted with the maximum number of variable factors, so that experiments require the maximum amount of consideration and care in laying out and maintenance, and still more in drawing conclusions from results.

Ideally one should fix or eliminate all variables but one in a given set of experiments. Thus burning, grazing, weeding and soil-working can be dealt with by excluding burning and grazing, and doing the same weed cutting and soil working (or none), in a series of plots with varying manipulation of the canopy (512).

The full series for even-aged forest would include variations in treatment as regards manipulation of canopy with gaps of two sizes, strips of 2 or more widths, and shelterwood fellings of 3 intensities and clearfelling, (8 variations), weedings of at least 2 types and no weeding (3). with or without soil working (2), with 2 types of burning and unburnt (3), and with 2 intensities of grazing and ungrazed (3) a minimum of the impossible number of $8 \times 3 \times 2 \times 3 \times 3 = 432$ plots. apart from any repetitions. It is obvious that in practice one must form from general observation a hypothesis as to what selected few, say 8 or 10 of these 432 combinations are the most hopeful of success, and not bother about the rest till failure with the first selection necessitates another. Examples will be apparent to every worker and need not be specified.

In natural regeneration experiments there are a few special points of general application to be dealt with besides those which have been discussed above.

Firstly, it is as well to repeat the warning to take steps if necessary to prevent damage by wild or domesticated animals from spoiling the experiments.

Many important forest trees are characterised by passing through what is known as an "*establishment period*", during which above-ground growth is very slow or even *nil*, the shoots dying down at one season or other annually

for some years before rapid height development starts. The result is much the same where seedlings are burnt back annually till they reach a stage which survives the average fire. The consequence of this is that many regeneration experiments require differentiation according as to whether one is attempting to obtain new regeneration, or to establish already existing unestablished regeneration, the latter being much the commoner objective. Further, it becomes necessary to define for each species what constitutes an established plant, in order to record progress in regeneration. In *sal*, for instance, it has been taken as one having the base of the stem as thick as the thumb, say 1″ diameter, irrespective of height. There would be little difference if one took the attainment of a height of 5′ or 6′ as constituting establishment, since height growth remains below this figure till the 1″ diameter is reached and is then rapid; moreover as a rule, height is easier to work with. For other species, the term is often used rather differently, to mean plants which are strong enough to survive fire or weed competition, and so decidedly larger.

For most species, one-season-old regeneration is totally undependable, a severe drought or frost or fire being able to annihilate it. Regeneration of the season when separately recognisable, or regeneration below a certain size varying with the species, is best dealt with separately. The term "recruitment" has been suggested for *sal*, and may be adopted more generally; much or even all recruitment may fail to persist.

In each case, it should be decided on general grounds what definition is to be taken, and since a fixed standard is the important thing, it must be adhered to, even if grounds appear later for a minor change. Two or more stages will often require to be distinguished according to local conditions.

For typical important species, the following limits are tentatively suggested.

Species.	Recruitment stage R	Unestablished stage U.	Established stage E.	Sapling stage S.
Shorea robusta	1 season old with primary leaves. (Up to 1′ high).	Up to 1″ diameter at base usually thin whippy stems under 6′ high.	Stem at least 1′ diameter at base stout stems over 6′ high.	Over 12′ high and 2′ d. b. h.
Dipterocarpus tuberculatus	Under 2′ high . .	2′-10′ high . .	Over 10′ high under 1½′ d b. h. (5′ in India).	Over 10′ high and 1½″ d
Tectona grandis .	Under 2′ high . .	2′-10′ high (Burma) 2′-5′ high (India) .		
Pinus longifolia . .	1 season old (with cotyledons).	Without whorled branches.	With whorled branches	Over 10′ high
Cedrus Deodara .	1 & 2 season old plants (Up to 9″ or 1′ high).	Up to 3′ high.	Over 3′ high.	Over 3′ d. b. h.

The next matter concerns the spacing of the plants. To exemplify from an extreme instance, in a plot of 1 acre, regeneration is only one quarter complete if three quarters of it are blank, however dense and well developed the regeneration may be on the remaining quarter. The questions constantly arise:—What shall be taken as complete regeneration? Is a plot with seedlings of maximum spacing 10′ as well regenerated for practical purposes as one in which this figure is 3′? Hitherto we have usually been content with generalisations from optical observation, sometimes backed—in a misleading way as just illustrated—by figures for number of plants and average height.

It would clearly be useful to be able to express the position as regards regeneration in some simple numerical way, such as a percentage of complete stocking with established regeneration. Three premises are required to make this possible.

1. The number of plants per acre to be considered as full stocking.
2. The minimum spacing between seedlings for them to count towards this number.
3. The limit beyond which regeneration is taken as established.

In artificial regeneration, 6′ × 6′ is by far the most commonly adopted spacing for all species. 6′ × 6′ corresponds to 1,210 plants per acre, 1,200 or 1,000 being more convenient numbers to deal with and 1,000 is proposed for

the stages beyond R. For recruitment a higher number is obviously desirable, and 4,000 is suggested.

If the minimum spacing was to be 6′, *average* spacing would obviously be a good deal higher in most cases. 1,000 plants corresponds to about 0·8 stocking at 6′ × 6′ with an average spacing of 6·7′, whilst 5′ spacing means 1,742 plants per acre.

A minimum spacing of 5′ is suggested, meaning that for U. E. or S, a plant B should not be counted if another A, 5′ or less distant from it has already been counted, unless there is not a third C, within 7′ of it on the side further from A,* *i.e.*, if its removal would leave A and C over twice the required spacing (or 12′) apart. For R seedlings these figures will be halved, the spacing for the larger plants taking priority in a mixture. As a rule it will pay in an Indicator Plot to remove (or at least cut back) any seedling so excluded, but this may not be done if it will alter considerably the conditions for the remainder as compared with those prevalent over the Experimental Plot as a whole. The percentage stocking is thus readily obtained, and it remains to find a figure for average progress towards establishment dimensions. The height of each seedling (after exclusions for over-close spacing) is recorded and the average struck, and the ratio of this average to establishment height will give the required factor. Thus with an average height for 333 plants of 2·5′ and an establishment height† of 5′, the established regeneration percentage is expressed by $\frac{33,300}{1,000} \times \frac{2·5}{5} = 16·7$ per cent. The treatment of recruitment might vary with the species. If its persistence is very doubtful, it might be dealt with entirely separately (probably so for *sal*), but otherwise it would be included in the calculations as follows. 333 U + E, *plus* 250 R equivalent to $\frac{250}{4} = 62$. Percentage stocking $= \frac{(333+62) \times 100}{1000} \times \frac{1·8}{5} = 15$ per cent. Where elimination on spacing has not been done, the best 1,000 plants per acre can be similarly dealt with as the next best thing.

Regeneration which has passed the predetermined establishment limit may be similarly dealt with for overclose spacing as also may the recruitment stage where this requires to be studied. The position as regards regeneration of a 1 acre plot can thus be fully expressed by 3 figures.

1. Recruitment (R) per cent., say 20. (800 plants).
2. 5′ establishment factor, F_E, say 16·7 (333 plants average height 2·5 ft.).
3. 5′ established (E) per cent., say 4 (40 plants over 5 ft. high).

When an experiment starts with fairly advanced regeneration sufficiently widely spaced for mutual interference to be negligible, there is no need to heed the spacing, and the percentage stocking may be replaced by the percentage survival on the initial number.

This is an appropriate point to emphasise that in comparative experiments, *e.g.*, on the effect of burning and protection on establishment, the two indicator plots must be so selected that their initial condition as regards " recruitment ", establishment factor and established per cent. are as similar as possible, *i.e.*, if the figures given above 20 per cent., 16·7 and 4 per cent. hold for the one, the range for the other should, if possible, fall within limits of say 15 to 25 per cent., 12 to 24, and 1 to 8 per cent., respectively—local considerations determining which figure was of most importance. Many examples of existing plots could be quoted to show that this is by no means impossible, *cf.* Bhamó (Burma), Experimental Plots 6A and 6B, with *Pentacme suàvis*, for which the initial figures were—R = 23 per cent. and 15 per cent.; U = 100 per cent. and 100 per cent.; E = 20 per cent. and 19 per cent.; F_U = 84 and 82; F_E = 9 and 8. The progress of regeneration in the plots as shewn by the counts a year later, is then fairly assessed by the change from the original to the new figures which were—R = 12 per cent. and 7 per cent.; U = 100 and 100; E = 100 per cent. and 100 per cent.; F_U = 100 and 100; F_E = 70 and 76, shewing that the difference of treatment, in this case fire

* A divergence of approximately 30° on either side of the line AB produced, would be included.
† Trees over 5′ high are taken as 5′.

protection or burning, has not greatly affected the rate of progress in the short period reviewed.

2.—*Artificial Regeneration.*

Nursery and Experimental Garden work.—Nursery investigations differ rather from those carried out in the forest in that more intensive work, supervision and recording is possible, but the same principles hold for both. Every plot, bed or line should have a permanent number indicated on the ground. Every sowing or planting should have a defined object as usual, and all particulars recorded.

A form of which Experimental Form 5 is a revision has long been in use and has served very well for seed beds and most other cases, but Form 3, providing for measurements or notes on individual plants or patches, will often also be needed particularly for transplanting experiments, or Form 4 may be preferable, such classes as very vigorous (2v) vigorous (v) normal (n), weak (w) and very weak (2w)—or straight-forward heights being used, and the number of plants, (or patches carrying such plants) of each type recorded at each inspection instead of actual measurements and notes on the individual plant.

For comparative investigations which are similar to the forest experiments, *e.g.*, the effect of the use of a particular manure on seed bed development. it is best to follow the procedure described above under Section VII, Initial Records, p. 16, maintaining Form 2 for comparisons between the two or more beds constituting the set—in this case, keeping them with the Form 5.

For summarising the results from a nursery bed or set of beds (repetitive or comparative) both during development and finally, Experimental Form No. 6 has been devised, whilst Form No. 7 provides a summary, suitable for record on the specific files of Form 5 (as also does Form 3, if it has been used) for artificial regeneration.

For comparing or contrasting results from comparative tests, the right hand side of the Form 6 is divided into two columns which can be ignored for single plot records and for all entries common to all the plots being compared, or can be further sub-divided if necessary.

3.—*Seed Testing, etc.*

It is owing to lack of uniformity in cleaning, and conscious and unconscious grading, that existing data for germination and plant per cent. are so unreliable.

Purity per cent. should first be determined by weight: 2 or 3 weighed samples of seed as collected being cleaned of all foreign matter, pieces of fruit, etc., and reweighed; as large a quantity as possible should be used for each test. With the clean seed so obtained the further tests can be carried out.

Many seeds, especially those of conifers, can readily be graded by size by sieving, and if for example the small seed is decidedly inferior, it may be worth removing it to get the better results and perhaps save transport and further handling charges. In investigating the effect of size of seed on germination and development, as expected differences are small, a larger number of tests is called for, say 5 for each grade: it should be definitely recorded whether the seed is all from the same tree or not. Five grades form a convenient number. Larger seed such as *sal* can be graded by hand using a plate with holes of different known diameters.

In all seed tests it should be recorded whether there has been any selective rejection of imperfect or insect-attacked seed which has passed the usual cleaning processes.

The quality of the seed can be roughly assessed by the ordinary cutting test on 100 seeds. A biochemical method of determining the vitality of seeds by measuring their catalytic activity in liberating oxygen from oxygenated water has also been proposed but it is not likely to be of much use to the

forester in India. For most purposes actual germination of the seed is desirable for finding its quality.

Germinative power may be determined in various ways using porous plates, wet blotting paper, wet cloth, sand, charcoal or soil as *media*. Each method has its own peculiarities, so that comparative tests must all be done in the same way, which must be described in the record. Each different type of seed usually tends to give more regular results with one of the methods than with the others. The product of the germinative power and the purity per cent. gives the *Utilisation value*. Germination tests are sometimes continued for a limited number of days only and the number of seed out of a hundred which germinate, is the *germination per cent.* Pending a generally accepted standard for the period, this figure is of less value for comparative purposes than the germinative power, though practically it is probably more important.

Experimental Plot Form No 1.

SITUATION MAP *of Experimental Plot No.* *Division.*

Scale. *Inch* =

[Note.—This form is printed on durable paper suitable for receiving a traced outline.]

Experimental Plot Form No. 1a.

MAP *of Experimental Plot No.* *Division.*

Scale. One inch = *feet.*

[Note.—This form is printed on durable paper suitable for receiving a traced outline.]

[Becomes Form No. 2, Plot Map.—*Ed.*]

Experimental Plot Form No. 2.

DESCRIPTION *of Experimental Plot No.* *Division.*

1. Species

2. Object of experiment

3. Date of formation

4. Area in acres

5. Situation

6. Altitude

7. Climate

8. Mean Annual Rainfall

9. (*a*) Rock

(*b*) Soil

(*c*) Humus

10. Aspect and slope

11. Type of Forest

12. Initial condition of plot

(*a*) Overwood

(*b*) Underwood

(*c*) Weed growth

(*d*) Regeneration of principal species

13. Details of work carried out at first formation

14. Details of treatment to be applied

15. Probable intervals and season of inspections

16. Remarks

[Note.—The spacing should be arranged to provide for two lines of typescript or one of manuscript.]

[Becomes Form No. 3 with rearrangement of entries 6-10.—*Ed.*]

Experimental Plot Form No. 2—(*contd*).

SUBSEQUENT HISTORY *of Experimental Plot No.* *Division.*

Date.	Particulars.	Signature.
	[NOTE.—Printed on both sides of the paper.] [Becomes Form No. 4 with alternative heading 'PERIODIC SUMMARY'.—*Ed.*]	

Experimental Plot Form No. 2*a*.

PERIODIC SUMMARY. *Experimental Plot No.* *Division.*

Date	Summary.	Signature.
	[Combined with previous form.—*Ed.*]	

TREE CHART.

Scale 1″=

Experimental } *Plot No*
Indicator }

[This form will be printed on squared paper.]

[Becomes Form No. 5.—*Ed.*]

Experimental Plot Form No. 3a.

Division.

NOTES—

Use different marks for each important species, *e.g.*, +, ⊙, ⊡, ×, etc.

If associated woods are to be shown, always use * for them.

Symbols and Abbreviations—

\+ =

⊙ =

⊡ =

× =

Date and Observer.

1.

2.

3.

4.

5.

6.

RECORD OF MEASUREMENTS.

Experimental Plot No. *Division.*

Indicator Plot No.

1. Area and shape
2. Situation
3. Demarcation
4. Date of formation
5. By whom laid out
6. Surrounding and overhead cover
7. Undergrowth
8. Soil

Date.	Analysis of Observations.					
	Species.	Total No.	Minimum.	Maximum.	Average.	Observer.

Note—

1. Measurements should be given all either in inches or in feet, the symbol being written against the first entry.
2. Each major species should be given a separate series of numbers from unity.
3. The following abbreviations and symbols are used to describe condition: absence of anyof them implies normal condition.

X—disappeared.	b—with small buds.
O—vacant space from start.	B.—with large buds.
W—weak.	T.—top broken or browsed.
Y—sickly, off colour or obviously dying.	II, III.—with 2, 3, shoots from base.
V—vigour above normal.	Y.—forked.
	ll—leafless.

[Becomes Form No. 6 with some modification of the Note and abbreviations.—*Ed.*]

Serial No.*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Species.																																
Date and Initials.																																

[This form is printed on a double sheet (lengthwise) and the sequence of numbers continued to 100.]

* NOTE.—If more than one sequence of numbers is required for different species, enter the new number below the printed one.

Experimental Plot Form No. 4.

SUMMARY OF MEASUREMENT AND COUNTS.

Experimental Plot No. *Division.*

Indicator Plot No.

Date and Initials.	Number in each type or class.												Total.	Remarks.
	1	2	3	4	5	6	7	8	9	10	11	12		(Figures resulting from calculations or selections to be bracketted and explanation given in this column. Abbreviations as given below and any other required.)

Abbreviations.

x=disappeared.
v=vigorous.
n=normal.
w=weak.
y=sickly.
c=new shoot from base.
t=top broken.
Y=forked.
R=recruitment.
U=unestablished, meaning.....
E=established, meaning.....
S=Sapling Stage, meaning.....
.....
.....

[Becomes Form No. 7 turned lengthwise on the page, with 16 class columns and revised abbreviations.—*Ed.*].

Experiment Form No. 5.

SILVICULTURAL GARDEN_____

*Plot, Line or Bed No.*_____

Species_____

Origin of seed_____

Object of experiment_____

_____

Date of { Sowing_____ / Transplanting_____

Date and nature of soil preparation_____

Spacing_____

Size of transplants_____

Watering, weeding and shading to be done_____

_____

_____

Other particulars_____

_____

_____

_____

Subsequent observations.

Date.	Observations.	Signature.
	[Continued on the back of the sheet.]	

[Becomes Form No. 8, the signature being included in the date column.—*Ed.*]

Experiment Form No. 6.

SUMMARY (Nurseries).

(*Kaunli*)—Experimental Garden. *Bed Number.* 15—18

	15	16	17	18
1. Species	*Adina cordifolia.*			
2. Origin of seed	*Collected locally.*			
3. Date of collection	*20-4-1926.*			
4. Storage condition	*In gunny bags under cover.*			
5. Seed treatment	*Nil.*			
6. Date of sowing	*24-6-1926.*			
7. Mode of sowing	*On normally prepared nursery bed.*	*Ditto: grass burnt on bed and seed sown in ashes.*	*Grass and debris burnt and ashes worked into soil.*	*¼" bajri spread on normal bed.*
8. No. or quantity of seed	*2 oz.*	*2 oz.*	*2 oz.*	*2 oz.*
9. Germination commenced on	*2-7-26*	*3-7-26*	*2-7-26*	*30-6-26*
10. Interval between sowing and germinating in (*days*).	*8*	*8*	*8*	*6*
11. Germination mostly over by	*24-7-26 for all.*			
12. Germinating period in (*days*)	*16*	*15*	*16*	*18*
13. Final plant per cent. on (*31-10-27.*)	*·0006*	*·0016*	*·0012*	*·0020*
14. Subsequent development—				
Date	Average height (Maximum) and Survival per cent.			
31-10-26	*1·7" (3·5)*	*2·2" (5·5)*	*2·5" (7)*	*2·0" (4)*
1-4-27	*2·5" (5)*	*3·5" (7)*	*4·0" (9)*	*3·0" (6)*
1-7-27	*9·0" (16)*	*14" (22)*	*16" (24)*	*12" (20)*
31-10-27	*22" (32)*	*26" (40)*	*30" (46)*	*24" (36)*
15. Conclusions	*The best result is obtained by burning debris on the bed and working the ash into the soil before sowing. Omission to mix in the ash appears to result in some loss. Spreading ¼" bajri on the bed is definitely beneficial as compared with the untreated control and gave the highest plant per cent. The initial development in the year of sowing has determined subsequent growth.*			

[Becomes Form No. 9.—*Ed.*]

Experiment Form No. 7.

ARTIFICIAL REGENERATION.

SUMMARY.

Experimental Garden, Kaunli. *Plot or Bed Number D1 & 2.*

1. Species	*Cinnamomum Camphora.*		
2. Origin of Seed	*Kaunli Garden.*		
3. Date of Sowing	*1st December 1919.*		
4. Preparation of Area	*In May pits 1½' × 1½' diameter, 5 feet apart.*		
5. Date of Transplanting	*14th July 1921.*		
6. Age when Transplanted, in *months*	*20*		
7. Method used	*Entire transplants 9" to 4'—5" high with roots 10"—18". Plants weeded but not watered.*		
8. Number of Plants	*50*		
9. Subsequent Development	.....		
Date.	*Average Height.*	*Maximum Height.*	*Survival per cent*
8th September 1921	*27"*	*51"*	*86*
8th April 1922	*26"*	*51"*	*80*
23rd September 1922	*29"*	*50"*	*62*
6th April 1923	*29"*	*53"*	*62*
20th September 1923	*36"*	*80"*	*62*
17th April 1924	*49"*	*103"*	*62*
19th September 1924	*84"*	*134"*	*62*

10. Conclusions

20 month-old entire transplants put out in pits 1½' deep by 1½' diameter in mid-July, when 10'—50" high, weeded but not watered, suffered some losses during the following hot weather, with 62 per cent. survivals and no further losses during the next two years. Development was almost nil in the first two seasons, after which it was rapid, an average height of 7' being attained after 4 seasons from transplanting.

Signed A. B. C.

The 15th October 1924.

[Becomes Form No. 10.—*Ed.*]

Experimental Form No. 8.

GERMINATION TEST.

Locality of Experiment _____ Test No. _____

Species _____

Origin of Seed _____

Date of Collection _____

Particulars of Storage and Pretreatment _____

_____

_____

_____

Appliance used _____

Number of seed used _____

Date of commencement _____

Date.	Number of days from commencement.	Number germinated.	Number rejected (for rot, etc.).	Remarks.

[Becomes Form No. 11.—*Ed.*]

ITEM 7.

IMPORTANCE OF ORIGIN OF SEED IN ARTIFICIAL REGENERATION AND AFFORESTATION.

This subject was suggested for the Agenda by Madras, and the only printed paper was by Mr. A. A. F. Minchin (Madras), *vide* p. 72.

Brief notes were submitted by Assam, the Central Provinces and the United Provinces.

The debate was opened by Mr. Chaturvedi (United Provinces) who gave a short summary of results obtained in the United Provinces with teak seed from various sources, and drew attention to an American paper which suggests that weakly seedlings also have a useful function in pure woods. This summary was circulated; it read as follows :—

1. That the origin of seed is of considerable importance will be easily conceded. In the United Provinces, we have carried out an investigation to ascertain the comparative viability of teak seed obtained from various sources. Seed was obtained from—

(1) Central Provinces, (2) Jhansi, and (3) Burma.

While results to date indicate that Burma seed is easily the best, the Central Provinces seed was found equally good for dry *bhabar* localities. In Gorakhpur, the local† seed has been found to be as good as that imported from Burma. Thus, it will be seen that local conditions would influence the choice of the source of seed to a large extent.

2. We, in the United Provinces, have been importing teak seed from Burma to the extent of 150-200 maunds a year. The question has now come up about the comparative viability of seed obtained from different divisions of Burma itself.

3. The importance of obtaining only the best seed, and discarding the under-sized seed is rather apt to be exaggerated. For pure woods, as long as a sample of seed contains a fair amount of large individuals, the selection of seed is not of much importance*. The seedlings obtained from such a sample would vary in size and vigour. When such seedlings are put out in forests a healthy competition sets in early and the best individuals soon suppress the weaklings. The weaklings have no other function than to kill the branches of trees which would form the future crop, preserve the soil and keep out weeds. Why then, have a uniform crop of sturdy seedlings to start with? This will only prolong the competition, and would involve thinnings which otherwise could be dispensed with if a fair per cent. of the plants are initially weak. The poorly developed seedling will do the job it is intended to perform without interfering with the development of the seedling which is to constitute the future crop. The practice of putting out only the best and well developed seedlings in an area is, therefore, of doubtful value. A sample of seed with a fair proportion of large and small seeds is to be preferred to one which contains only large or small seeds. Nature produces such a mixture of seed to ensure natural selection among individuals.

* * * * * * *

The further debate which followed, touched on the questions of the effect of age and dominance of parent trees, examples of transmission of racial characters, the importance of altitudinal range for such species as blue pine, and treatment of teak seed, many members taking part (*cf.* p. 75).

A resolution was proposed by Mr. Trevor (Forest Research Institute) and seconded by Mr. Blanford (Burma), and passed.

---

* 1. George Leven. Seeds as a factor in Silviculture. Quarterly Journal of Forestry, Oct. 1928, p. 247.

2. Somerville, W. Quoted by George Leven in the above.

† *I.e.*, seed from local introduced trees: teak is not indigenous in Gorakhpur.—*Ed.*

RESOLUTION 7.

RESOLVED *that the Central Silviculturist should prepare an abstract of the latest European experience on the influence of the origin of seed (seed bearer and locality) on the plants produced. He should suggest lines of research in collaboration with Provincial Silviculturists.*

PAPER

Contributed by

A. A. F. MINCHIN, *Conservator, Working Plans Circle, Madras.*

1. Attention was drawn recently to this subject by observations made by the Madras Working Plans Conservator, Mr. Wimbush, when inspecting certain Nilambur teak nurseries in 1926. Certain seedlings were what would be characterised there as thoroughly bad,—thin and whippy. The seed used had, it was ascertained, been collected from Plantation teak trees. [Mr. Bourne's working plan of 1917-18 in fact specifies, " Teak seed shall be collected . . . only from good teakwoods of middle age ".] Another nursery contained some much better plants raised from seed from another source, Mount Stuart natural forest trees. It is not an infrequent occurrence for local seed to run short at Nilambur. At such times, seed obtained from very widely different sources has had to be employed, but unfortunately track has not been kept of the resulting plants.

2. Obviously it cannot be supposed that origin of seed is a sole determining factor accounting for well, or badly conditioned nursery plants, yet there are grounds for suspecting that it is an appreciable factor. In the report on Forest Research in India, 1926-27, page 55, the following passages appear under " Experimental Silviculture in the United Provinces ".

> " For some years past numerous experiments have been carried out in several Divisions to try and ascertain the best method of germinating teak seed, from which fairly conclusive and rather unexpected results have now been obtained . . . . . (*c*) Teak seed from Burma :—Most expensive source of supply, but results obtained are easily the best. Seed kept until the following April and sown in irrigated nurseries, germinates very quickly and the germination has been reported from 100 to 200 per cent. (Each teak seed has 3 embryos from which sometimes 2, sometimes 3 seedlings are obtained.) Subsequent seedling development is also very good."
>
> " The conclusion that can be drawn is that the method of sowing and germination is of minor importance compared to the source of supply, and as soon as the Province can obtain a good supply of Burma seed a year in advance, the problem of teak seed germination will have largely solved itself."

3. It was decided to set up on simple lines at Nilambur an investigation of the relative merits of teak seed from four distinct sources, and an account of the lines adopted will be given. The account given may at least lend itself to criticism by the Conference.

4. The subject could be investigated on complex lines. Results from numerous variations in nursery practice might be required. Again results obtained in one season might differ from results in another season by reason of temperature and rainfall variations. This could be overcome by repetition. So far, in one experiment, the sources of seed employed have been limited to three distinct local sources and one " non-local " type, namely Anamalais teak.

5. The object in view has been defined as " to watch the quality of plants obtained from different types of teak seed; and by planting out each type in separate lines, to ascertain to what degree one or another of the types does best under given conditions ". But it may be added that (*a*), we expect our nursery plants to be ready for transplantation into the regeneration area

by the break of the monsoon, and (*b*), that short sturdy plants are the type preferred.

6. The teak seeds employed were from (1) Anamalais Hills natural forest, that is to say from Mount Stuart neighbourhood in the South Coimbatore Division; (2) Nilambur natural forest, Nellicutta block; (3) Nilambur Plantation teak trees, Elenjeri 1846 plantation: *in these three cases, from the best class of seedbearer to be found;* and (4) from unselected plantation trees, Aravallakava 1851 plantation.

In all four cases very undersized seeds were discarded.

Of each type, equal quantities by volume were sown in three types of nursery bed, at an espacement of about $1'' \times 1''$, leaving $\frac{1}{2}''$ to $\frac{3}{4}''$ between adjacent seeds. The types of nursery-bed were as follows:—

(*a*) Raised bed, 3′ wide, 6′ long, supported at the sides by split bamboos.

(*b*) Ordinary Nilambur-type bed, somewhat sunk, with low retaining mud walls, beds 30″ wide, and 6′ long, within the " walls ".

(*c*) Bed similar to (*a*) but without support. Ground flat, alluvium, soil dug, according to local practice 2′ to 3′ deep previous to formation.

In one set of twelve beds, *unsoaked* seed was employed. In a corresponding set seed *soaked* in water for 48 hours, (the general Nilambur practice), was used. The experiment involved therefore 24 beds.

On April 15th and 16th sowing of the " unsoaked " series was completed, and on 17th that of the " soaked " series.

In sowing, the seeds were pressed lightly into position and then covered with a thin layer of soil.

7. Dated observations of germination and development of the seedlings have been recorded at short intervals in the plot file.

Local practice is to plant up a regeneration area with plants, spaced about $6' \times 6'$, straight from the seedbed. Short stocky seedlings with but four or five leaves developed, are preferred. To follow the future of the plants under experiment, an area adjacent to the nursery has been constituted a testing ground, lines of plants of the several seed classes being formed.

8. Observations made by the Forest Research Officer on 17th May, a month after commencement, regarding comparative rapidity and evenness in germination, were to the following effect:

Nilambur natural forest seed, soaked,—good.

All others,—poor to very poor.

So far as the three types of beds were concerned, little difference; but the sunk, Nilambur regulation type of bed had done best. So far as teak is concerned this was not unexpected, for the sunk type retains the seed in a moister state than the others: and teak seed needs this, if germination is to be expeditious.

9. By June 5th the plants from Nilambur natural forest soaked seeds, in all three types of bed, were rather tall and crowded, whilst the germination was still proceeding vigorously in all the other beds, and seedlings were at various stages of early development.

On 13th June and again on 23rd June the Research staff, to the best of their ability, placed in an order of merit the results in the test beds, *both rapidity in germination, and quality of plants being considered.* The resutls are no doubt of purely local interest; however, the following was the order of merit on 23rd June, a date by which most of the planting out would ordinarily have been completed but for an eccentricity of the 1928 monsoon. The criterions were evenness and rapidity of germination, and sturdiness or otherwise of seedlings.

(1) Nilambur natural forest seed. Soaked. Sunk bed.

(2) Nilambur natural forest seed. Soaked. Raised bed with supports.

Plantation selected tree seed. Soaked. Sunk bed.

(3) Nilambur natural forest seed. Soaked. Raised bed without supports.

Plantation selected tree seed. Soaked. Raised bed without supports.

(4) Plantation selected tree seed. Soaked. Raised supported bed.

Plantation unselected tree seed. Soaked. Raised supported bed.

Plantation unselected tree seed. Soaked. Sunk bed.

(5) Plantation selected tree seed: *not* soaked. Sunk bed.

Plantation selected tree seed: *not* soaked. Raised bed unsupported.

(6) Plantation selected tree seed, *not* soaked. Raised supported bed.

Mount Stuart natural forest seed, *not* soaked. Raised supported bed.

(7) Nilambur natural forest seed, *not* soaked. In all three types of bed.

(8) Nilambur Plantation unselected tree seed. Soaked. Raised unsupported bed.

Mount Stuart natural forest seed: *not* soaked. Sunk bed, and raised unsupported bed.

Nilambur Plantation unselected tree seed. *Not* soaked. In all three types of bed.

(9) Mount Stuart natural forest seed. Soaked. In all three types of bed.

Whilst the " placing " was a difficult matter of judgment, the differences between, say Nos. 1, 5, and 9 were very readily discernable.

Mount Stuart seed took much longer than the others to get under weigh; and the soaked seed gave worse results than the unsoaked.

Apart from Mount Stuart seed, soaked seed gave *much* the best results in even and quick germination.

Soaked natural forest seed did *far* better than any others.

Unsoaked natural forest seed however did distinctly worse than unsoaked plantation selected tree seed.

There was little to choose between soaked Plantation seed from selected trees, and unselected trees.

The sunk type of bed gave better results than the raised beds, and of the raised beds those supported at the sides did perceptibly better than the unsupported beds: possibly the former retained a higher moisture content.

Regarding the merits of the plants put out into the adjacent plantation-lines it is too soon to speak.

We find one object, in producing the small sturdy type of plant on the due date, was imperfectly fulfilled. A means of exercising a check over height growth seems to need consideration. Further, selection of individual seeds of optimum size and shape received little attention. In 1929 we contemplate repetition and some extension of the scope of the investigation.

It is suggested that a resolution to the following effect be placed before the Conference: " Recognising that the merits of seed from seedbearers of differing characteristics and localities is a subject deserving of investigation, this Conference recommends an exchange of views between provincial research officers and the Imperial Silviculturist, both concerning any observations already recorded and also concerning the lines on which future investigation should be conducted ".

In conclusion though outstanding success was achieved with seed from selected local natural forest teak trees there is always an insufficiency of such seed. We have it in mind to try to induce selected trees to seed profusely. Suggestions would be appreciated. if experience has been gained elsewhere in stimulating seed-production.

REPORT OF DEBATE.

Mr. Chaturvedi: Regarding the actual resolution, I feel that the Central Silviculturist is in a unique position to investigate the effect of age, dominance and locality of a tree on the fertility of its seed. I understand that such experiments are already in progress in the New Forest nurseries. As a matter of fact, experiments on heredity in seed are already on the Central Silviculturist's programme. Whilst I do not deny that provincial silviculturists could also contribute towards the solution of this problem, the need of this type of intensive research to be carried out by the Central Silviculturist may nevertheless be emphasized. In the provinces, facilities to carry out this type of work usually do not exist.

Mr. Champion: I do not know if every one will agree with the last paragraph of the note Mr. Chaturvedi has passed round, [*cf.* p. 71], because while the arguments may apply to natural regeneration, they are certainly unacceptable for our relatively widely spaced plantations, and to nursery work for transplants. We generally use in our sowings a limited amount of seed, and it seems to me more or less common sense to use the best seed we can get.

The work which Mr. Chaturvedi refers to that we are doing here is, I am afraid, not of very great importance. We can only deal with two or three species indigenous here, and the type of thing I think he is referring to has already been studied in detail in Europe. The conclusions reached there, if applied under Indian conditions, would not make very much difference to our present practice.

Particularly as regards nursery transplants, with seed from trees of a given strain, a seedling of given vigour type will shew the same development whatever crown class of parent it originates from.

These results, such as they are, are perfectly well established, and it is not practicable, as a rule, to make a careful selection in the forests when you have to collect a lot of seed. One important point refers to our ordinary methods of collection: there is definitely a tendency to collect seed from the worst shaped trees. That is very definitely the case with *Pinus longifolia* and certainly occurs with many other species. (General assent was expressed.) The particular case of spiral grain in *chir* pine is, I think, quite conclusive enough for general purposes, so I do not want people to expect me to provide further proofs in that direction. If it is possible, I would suggest collecting all your seed, or the greater part of your seed, in felling areas, from the best trees, to the exclusion of the more usual method of sending out villagers to collect it from the trees easiest to climb. That is the best we can do.

I have an interesting note just received from Mr. MacDonald in Etawah Division, United Provinces. As an example of the importance of the selection of seed, it has been stated that it made a lot of difference in Etawah whether the *babul* sown was of a local deep rooting strain or an imported shallow rooting form (from Hamirpur). I am afraid I am always very suspicious of such statements until I see the actual data on which they are based, so I sent the note to Mr. MacDonald. His reply amounts to saying that the statement is not a justifiable deduction from the facts.

There is one very interesting point in which we seem to be getting results rather in contrast with European experience. In India proper, we have all been trying Burma seed, and comparing it with local indigenous teak or in some cases with locally collected seed from trees imported at some prior date. On European experience, you would expect at once that the results obtained with your own best local stock would be better than anything imported from other areas of decidedly different climatic factors. In India on the contrary, in a considerable majority of cases, better results are reported with imported Burma seed than local seed. Mr. Robinson, however, found his own seed better in Coorg. [One or two similar cases were mentioned by members.]

I would recommend a combined study for teak on the lines on which Scots pine has been dealt with in Europe. I dare say most of you are familiar with the experiments initiated 15 or 20 years ago now, by the International Congress of Research Stations.

Seed would be collected from some 8 localities—

1. Burma (probably 2 or 3 localities).
2. Madras (dry and moist types).
3. Central Provinces.
4. Bombay (dry and moist types).
5. Acclimatized trees where teak not indigenous.

It should be simultaneously tested in all the localities where the seed was collected and all other areas (United Provinces, Assam, Bengal) growing teak. One acre per type will suffice, but repetitions are desirable on account of unnoticed soil inequalities. It would not be necessary to raise all types at all places, a judicious selection being the better plan.

A comparative study for *chir* pine seems desirable particularly in connection with the big demand from abroad.

No other species except possibly *Gmelina* are important in this connection at present.

Mr. Minchin: I have very little to add. But in Mr. Chaturvedi's note, he says " why then have a uniform crop of sturdy seedlings to start with ". I would emphasize the point which Mr. Champion makes, which is that weakly seedlings are very apt to show their weakness in their very early years. A point of possible interest to members is that we experimented in Madras—and I gave some lengthy notes on the experiments carried out—on seeds from various sources, and we got very widely different results in the nursery in point of quickness, in germination and production of sturdy plants. We followed up the experiment by putting the plants out into the forest, and hope to reach some further conclusions after a season or two.

Mr. Champion: With regard to the last point, I think that it is the general experience of previous workers in this field, that the experiments are practically complete when you have got the seedling. As long as you deal with a range not greater than probably exists in this series, *i.e.*, a single strain, once you get a healthy seedling say 3″ high, it will always carry on in much the same way. Reported results are often extremely unconvincing on subsequent development, because the conditions are totally different in a densely stocked nursery bed from those in a nursery bed in which there is a seedling here and one there.

[There was some further discussion on this point.]

Chairman: I think the debate has shown that there is a good deal in the selection of seed, and that it is still an important matter, and that we have to go to the bottom of the matter. I think that we should continue to carry out experiments on the lines that Mr. Minchin has carried out, and try and have plantations in small areas.

There is one point which has not been made clear and that is with regard to Mr. Chaturvedi's statement about the unimportance of having all good plants. All over the world at the present day in plantation work, everybody is striving for wider and wider spacing. Many people take up the attitude " Why spend so much money in planting when in a few years' time you cut it out and chuck it away ". Certainly when I was a student people talked about 4′ by 4′ spacing. Now-a-days you hear more about 8′ by 8′ than 4′ by 4′ spacing, and in many cases spacings of 10′ by 10′ and so on are talked about. If you can get successful plantation by 6′ by 6′ or 8′ by 8′, it would be a mistake to adopt 4′ by 4′. But there is one important point. Whether you have wide spacing or not, you must have plants of first class vitality, capable of growing up together on a uniform basis. You don't want to have *any* inferior plants. In wider spacing, every single plant must contribute to the crop.

There is another matter as regards the after effect of the origin of seed which has not been mentioned, and that is a question of elevation. I can't help thinking that in the case of a tree like blue pine which grows at elevations say of 3,000 ft. to 10,000 ft., and in a variety of climates—for it grows

in the outer moist and also in the inner drier zones of the Himalaya, there must be very considerable difference in seed and in subsequent development of seeds from trees obtained from various parts of the range.

I propose that seed be obtained from various parts of the ranges and tried at several elevations. The seeds from the higher elevations were better, but it is a subject which is well worth investigation, and I should certainly like to see experiments being carried out on a scientific basis.

(Mr. Glover spoke further on this point confirming the Chairman's suggestions.)

It would be very instructive to have a book on Indian Forestry with photos of plantations grown from seeds of different origin. I think apart from altogether scientific interest the question of investigation of the results is a matter of real importance in the Forest.

Mr. Champion: That is the importance of collaboration in this matter. I rarely get a report from the provinces, unless I ask for it, and I think a great deal of trouble would have been saved had we all been working together and any results obtained were circulated to all provinces. I think a reasonable *selection* from among the many combinations of seed origin and site for test should be made to cover the range for each site; it should be quite easy, in view of the guidance we could obtain from the results already obtained in Europe.

Chairman: Would anybody else like to speak on this subject.

Mr. Sher Singh: As regards *kail* I think we should point out that in the collection of *kail seeds* it is most important not to collect any seeds from diseased *kail.* I imagine the fungus could be transmuted through the seeds?

Chairman: It is not possible.

Mr. Champion: Gentlemen might be interested to see the teak in my nursery and in the Demonstration Area. I don't mean to say that you should see it because it is a model nursery but because we have there teak from Burma, Central Provinces, Coorg, Jhansi and N. India. A point worth noticing is the marked difference in appearence between the Nilambur and Coorg teak and all the rest. The Burma, Central Provinces and United Provinces teak have the same appearance as regards shape of leaves, etc.

ITEM 8.

THE PROBLEM OF THE PURE TEAK PLANTATION.

Papers were contributed by Messrs. Shirley (Burma), *vide infra* and Minchin (Madras), *vide* p. 83.

Comments on these papers were sent in by Mr. Newman (Chief Conservator of Forests, Bombay), Mr. Blanford (Burma), Mr. Robinson (Coorg), and Mr. Homfray (Bengal).

The debate (*cf.* p. 87) was opened by Mr. Shirley (Burma), who summarised the papers and notes. All the above mentioned members took part in the discussion as also Messrs. Barrington (Burma), Champion, and Osmaston (Bihar and Orissa). The discussion covered experience gained in all parts of India and Burma of (*a*) methods of mixture as understorey or in the upper canopy, (*b*) methods of introduction of other species from coppice, planting or sowing, (*c*) suitable species for admixture, notably various bamboos and *Xylia*, (*d*) special difficulties with *Bambusa arundinacea*, (*e*) the relative exposure of pure and mixed crops to the attacks of bee hole borers and defoliators, and (*f*) fire damage and erosion, in pure teak plantations.

A resolution proposed by Mr. Barrington (Burma) and seconded by Mr. Minchin (Madras), was put to the Conference and passed.

Resolution 8.

Resolved *that, recognising that the production of crops of teak without either admixture or an undergrowth is inexpedient, and in view of the inadequacy of our present knowledge of the methods by which a mixture or undergrowth can best be obtained, this conference recommends—*

(*1*) *that the Central Silviculturist should collect and publish as a bulletin all information at present available;*

(*2*) *that experiments dealing with the admixture of teak with other species, or with the introduction of an undergrowth, should be undertaken by the Silriculturists of the Provinces concerned, and*

(*3*) *that the subject should again be discussed at the next conference when further experience has been acquired.*

Paper (*i*)

Contributed by

G. S. Shirley, *Silriculturist. Burma.*

The problem has arisen under three heads. First silviculturally, because, although most plantations have started well, there has undoubtedly been a distinct falling off in the rate of growth and general health of the plantations at about 18th to 20th year of age. Secondly as regards disease—mainly the bee-hole-borer and a rather vague fear of *fungus* attack. Thirdly, the problem of regenerating areas which have been under a pure teak crop. This last problem has not arisen in Burma, but if one may judge from the appearance of some of the older teak plantations, it will do so here just as it is reported to have done in Madras, unless early steps are taken to prevent its arising.

Some of the early records of the older plantations make it clear that at one time no thinnings were permitted unless they paid their costs. This was fatal in that teak, the strongest possible light demander, was grown under the worst possible conditions for such a species, as the suppressed and dominated trees which alone could be removed in thinning were naturally very slow in growth, and the thinnings were postponed for lengthy periods because the trees could not reach a marketable size.

When the question of dealing with teak plantations was gone into, all calculations were based on the European oak as being a representative light

demanding broad-leaved species. The result was that the figures for stocking per acre during the earlier period of life were very excessive, for oak is a comparatively slow grower in early years, and its habit of growth is entirely different from that of teak. It may be wise to grow oak in dense crops in order to produce straight stems free of branches, but teak grows perfectly straight naturally with a long leading shoot and requires an entirely different treatment.

The result of all this was that the rate of growth fell off as soon as the dominant trees met, and the plantations also contained large numbers of unhealthy suppressed and dominated stems. The canopy in a teak plantation never completely closes, that is, the branches do not interlace, and one can always see a distinct gap all round the crown of each tree. The reason for this is not far to seek. The buds of teak when it comes into leaf at the end of the hot weather and early rains are very tender, and strong winds often occur at this time with the result that the buds are broken off and the crown cannot expand. Constant damage of this kind and the healing of the wounds cause the trees to become crown bound.

Another result of overcrowding is that the undergrowth disappears, probably owing partly to the mechanical effect of the very heavy drip from the teak leaves, partly to the fires which take place owing to the enormous quantity of inflammable teak leaves which cover the entire area and burn readily, and partly, again, to lack of light. After the dying out of the undergrowth and the destruction of the teak leaves covering the soil, the drip from the crowns of the teak and the unrestricted passage of the water over the surface, erode the soil and expose the roots of the teak trees which are subsequently killed by fires. It is small wonder that trees which have been deprived of room for their crowns and deprived of their roots do not grow as well as we could wish.

A further disaster is that teak when grown without an undergrowth and in a crowded state invariably produces epicormic branches and when this happens the timber is fluted and mishappen.

The question of the treatment of pure teak plantations was discussed from time to time for several years, but although some fairly heavy thinnings were carried out in the Pyonchaung Reserve, North Toungoo Division as early as 1922, the general opinion seems to have been against heavy thinning until the appointment of Mr. H. R. Blanford as Silviculturist in 1920. After studying the question in various divisions in Burma, Mr. Blanford's conclusion was that the best treatment for teak is to thin early, to thin heavily and to thin frequently. This treatment has now been adopted, omitting the repetition for which there has not yet been time, and no one who is in a position to compare the plantations as they now are with what they were, can fail to be convinced that the treatment is correct. It is true that it has taken the trees in the older plantations some time to respond to the treatment, but little else could be expected considering the initial condition of their crowns and, in too many cases, of their roots.

We have not yet been able to deal with the question of the protection of the soil and the provision of an undergrowth, but there is no doubt that there has been improvement in the soil cover generally as the result of the heavier thinnings. Where it has been possible to introduce fire protection the improvement is very clearly marked, there is even in some cases a considerable quantity of bamboo which must somehow have survived.

Attempts at the provision of an undergrowth by underplanting have not been attended with any success when other timber producing species are used, nor is this type of undergrowth best suited to the purpose even if it succeeds. The best and the cleanest teak timber is undoubetedly produced in bamboo forest and if we wish to provide an undergrowth we may well learn from nature. Complete success has been achieved on a small experimental area which was sown in 1915 (by Mr. Blanford) under a teak plantation of 1898. The result could not be more satisfactory. With the encouragement given by this example, experimental sowings of bamboo have been made during the past year and are being continued. The first reports were disappointing

as most of the bamboo seedlings died back but, in spite of fires, they have thrown up new shoots with the breaking of the rains and there is every prospect of satisfactory results.

The problem of the silvicultural treatment of pure teak plantations is therefore practically solved. But shortly, we must grow our pure teak plantations as nearly in accordance with the conditions of nature as considerations of outturn per acre will allow.

The second problem in connection with pure teak plantations is damage by *fungi* and insects.

Very little is known of the damage done by *fungi*, but this in itself is a hopeful sign. Though the plantations have been grown in an overcrowded state there have been very few cases in which trees have died from the attack of *fungus*. Now and again reports have been received of small groups of trees which have died, and it has been assumed that a *fungus* was the cause, but there is no definite proof that this was so: in no case has the damage spread.

It is quite possible that *fungi* do considerable damage to the timber as it has been found in Java that *Corticium salmonicolor* has caused much damage by heart rot.

There are several insects which attack teak including defoliators and borers. In Burma the worst pest is undoubtedly the bee-hole borer *Duomitus ceramicus*, which the entomologists have renamed *Xyleutes*. The damage done by this borer is considerable although it does not kill the trees, and no means of dealing with it have yet been found. It is endemic in the forests and natural teak is, in some forests, very badly damaged. The only satisfactory feature as regards the borer is that it is never likely to become epidemic. Mr. Atkinson, Forest Entomologist, Burma, writes that "there is no question of endeavouring to check an epidemic and reduce it to its normal condition of comparative unimportance. The enormous annual damage caused by *Xyleutes ceramicus* is the result of normal conditions; the presence of the insect is of endemic and not of epidemic proportions".

An investigation into the comparative damage done by the insect to natural and plantation grown teak timber is now being carried out by Mr. C. W. Scott, Forest Research Officer, Utilization Circle, Rangoon. So far, it appears that the latter contains twice as many borings as the former and, considering the condition in which the plantations have been grown in the past, it is satisfactory to find that the damage is not greater.

It has been suggested that the pest could be controlled silviculturally by making small blocks of teak plantations divided either by blocks of natural forests or by blocks of plantation of other species. It is, however, to be noted first, that the older existing plantations have been formed in this manner and are yet attacked, and consequently once the insect has invaded the area, it is bound to spread throughout the plantation whether it is large or small. Secondly, that there is no likelihood that there will ever be an epidemic attack, and thirdly, that if the use of other species were to prevent the spread of the insect, which blocks of natural forest containing teak could not do, these other species, besides being of comparatively small value, are themselves just as liable to insect attacks as teak. We can and do sell bee-holed teak, but some other timber holed would probably be quite unmarketable.

We must accept the incidence of attack on natural teak trees as being the minimum, and our plantations must therefore be grown under conditions as similar to those in natural forests as considerations of outturn per acre will allow. Heavy thinnings and the introduction of an undergrowth are from a silvicultural point of view the most likely means of reducing the incidence of attack.

The third problem is the regeneration of areas which have been grown under pure teak.

It is not at all certain that we shall regenerate these areas by artificial means, and it appears at least equally probable that our rather scattered plantations will be grouped and worked on the selection system until a

final felling seems desirable. We have already experience of obtaining natural regeneration under an almost pure crop of teak, the system adopted being clear felling and burning and the result a very dense crop of young teak. Having placed the forests in a state in which they are capable of reproducing themselves naturally, there will probably be no need to make use of artificial methods, especially as, with a dense crop of young teak, the weedings are easily managed.

There is however one essential condition whether the forest is regenerated artificially or naturally, and that is that the soil should be in a suitable state; where it has been long exposed to fire and denudation conditions are unfavourable.

When selecting an area for artificial regeneration, bamboo forest is chosen by preference because past experience shows that such forest is most suitable for the purpose. The instance, quoted above, of the success of natural regeneration under an almost pure crop of teak shows that teak of itself does not injure the soil, for in this area the new crop, now 10 or 11 years old, is healthy and vigorous. Granted therefore that the plantations have been properly thinned and that an undergrowth, especially of bamboo, has been provided, the problem of the regeneration of areas which have been placed under teak should solve itself.

The treatment suggested for teak plantation is therefore :—

(1) *Early, heavy and repeated thinnings.*—Normally, thinning should start immediately after the canopy has closed. The age will depend on the rate of growth and the original spacing, but for plantations of ordinary growth spaced 6′ × 6′, 5 years will be the average age at which thinning should begin.

As regards the number of trees to be removed, it has been found in Burma that the figures worked out for the Nilambur teak plantations by Mr. Bourne are generally suitable. Roughly at the first and second thinnings in an average plantation, spaced 6′ × 6′ originally, 50 per cent. of the full stock should be removed on each occasion.

The frequency of the thinnings will depend on the age and rate of growth, but at no time should any struggle for existence be permitted. Up to 20 years of age at least, thinnings will ordinarily be required every 5 years, but the cycle will undoubtedly be lengthened as the trees approach maturity.

(2) *The provision of an undergrowth, preferably of bamboo, to protect the soil from erosion and to clean the stems of the teak trees of epicormic branches, which generally cause badly shaped boles.*—If bamboo is used it is obviously necessary, except in accessible areas, where the bamboos can be sold, to select those which will not overtop or interfere with the crowns of the teak. The depth of the crown of a teak tree in natural forests varies from $\frac{1}{3}$ to $\frac{1}{2}$ of the total height and, taking the lower figure, the bamboo should not be capable of growing to a total height of more than $\frac{2}{3}$rd of that of teak. In Burma, *Cephalostachyum pergracile*, of which incidentally seed can be obtained nearly every year, appears ideal for the purpose. *Dendrocalamus strictus* is also suitable from the point of view of size, but it does not usually occur under conditions best suited to teak. *Bambusa polymorpha* and *Dendrocalamus membranaceus* are too large for general use. At present, information as to the period which elapses between sowing and the attainment by the bamboo of its full growth is inadequate, but in the case of *Cephalostachyum pergracile* it is unlikely that the clump as a whole will have grown to its maximum height of 60′ to 70′ in less than 20 years. It is unlikely to grow to 70′ except on specially favourable soil on which the growth of the teak will also be above the average. If, then, the seed is sown under a normal plantation at the age of 20-25 years when the trees have reached a height of 60′ there can be no danger of the bamboo suppressing the teak. The seed of bamboo is eaten by birds, rats and mice and broadcasting or direct sowing is not likely to give good results, but it has been found by Mr. Mackenzie, Divisional Forest Officer, North Toungoo Division, that the seed can be germinated in 2 days on protected benches, and that

if it is sown after germination, it is free from danger. The germinated seed is best sown in patches on which the soil has been roughly hoed.

(3) *Fire protection and the use of fire.*—Fire protection should be the rule and teak plantations should be protected until it appears that a fire would be beneficial. To save expense an alternation of protection and burning may possibly prove satisfactory. Protection will almost certainly be necessary for a few years prior to artificial regeneration.

The following draft resolution is proposed for consideration :—

"*This conference is of the opinion that the most promising method of treating pure teak plantations is to thin from early years, to thin heavily and to thin at frequent intervals: to follow up these thinnings with underplanting, preferably with bamboo, as soon as the trees are so tall that the undergrowth will be unable to restrict the spread of their crowns. Fire protection should also be insisted on as a rule only to be relaxed after careful consideration of each individual case.*"

PAPER (*ii*)

Contributed by

A. A. F. MINCHIN, *Conservator, Working Plans Circle, Madras.*

1. Foresters in Madras have a belief that the production of extensive pure teak plantations is an unsound practice silviculturally: but it cannot be said that the practice has been discarded. Elsewhere, opinion may very likely be the same: I can only speak for Madras, and attempt to give the causes for our misgivings.

2. Taking "theory" first: we have been taught that production of extensive pure crops of any species is apt to be accompanied by the appearance of adverse phenomena, but that it is positively dangerous to grow extensive pure crops of pre-eminently light-demanding species. Of these teak is certainly one.

Coming now to "practice": we have in Madras many examples of artificial pure teak forests. The Nilambur plantations are the oldest and the most important. Naturally we are influenced much by Nilambur experience: the original plantations of 1843 and onwards are being clear-felled on a 70-year rotation basis, and from 1917 second rotation plantations of teak have been in process of formation. Our experience in the crops of both rotations has been disquieting. It would, of course, be incorrect to attribute adverse features in Nilambur Plantations solely to pure teak production: but the more serious faults cannot, we believe, be accounted for by faulty detail in treatment.

3. The main troubles are these. Firstly defoliation by a variety of insect pests. Defoliation, except in short periods of comparative immunity, is on a grand scale: at some times it is worse than at other times, but it is generally *bad*. The suggestion has been made that we lose through defoliation one-third part of the increment that should accrue.

Defoliation in natural forests with a strong teak constituent is far less serious and continuous than in our plantations. It results in Nilambur plantations in exposure of the forest floor, to varying degrees, during a great part of the year.

Defoliation is not confined to Nilambur. On the contrary, I know of only one small isolated teak plantation in Madras forests where defoliation is absent or inconspicuous.

Secondly, prevalence of epicormic branching on a scale that affects seriously the grade of timber produced, by reason of small knots. Epicormic shoots often appear immediately after thinnings, but are mainly associated with defoliation.

Thirdly, perhaps not a serious matter, Nilambur plantation teak trees are fluted far more than natural forest trees.

Fourthly, after a pure teak crop has been harvested. the ground is in a deteriorated condition by comparison with ground from which a natural forest crop has been removed. This is a generalisation: and has to be qualified. We are now re-planting what were the sites of the older plantations, and have learnt to expect bad or indifferent results from second rotation teak crops unless—if indeed we are fortunate enough to strike the right methods—measures to correct the essential features of soil-quality deterioration are adopted. Deficiencies in the second rotation crops, by comparison with first rotation crops formed by similar methods, are too regretably apparent to the eye to need demonstration by means of silvicultural statistics. However, in the earlier Nilambur plantations which are now being replaced by second rotation teak crops, there is known to have been a period in which clearance of all natural undergrowth below the teak was the practice. The middle-aged and young plantations, not subjected to such treatment—which was liable to expose the forest floor to an unnecessary degree—have an undergrowth to protect the soil. We have had as yet no occasion to fell and replant such areas: but whilst it is only reasonable to expect better second rotation results on them than on the old plantation areas, subjected to extreme exposure, the position affords little ground for optimism. The character of such natural undergrowth as we have is predominently deciduous.

Another, and perhaps a minor point in connection with objections to pure teak practice, is as follows. In carrying out artificial regeneration of a clear-felled area we have come to attach importance to securing a thorough burn of debris spread over the area. Thinnings reduce the stand of trees in a teak plantation: crowns of plantation-grown trees amount to but a small volume of debris: demand for branchwood of teak, for conversion into small-dimension material, still further reduces the debris: if girdling is in vogue, dry leaf and twig debris is still more deficient by the time we come to burn. As a result, in setting about the replanting of second rotation areas in Nilambur, we have had to put up with a burn that leaves very much to be desired.

4. Insect pest incidence and deterioration of the quality of the locality are phenomena that we have been *taught* to expect, as incidental to the production of extensive pure light-demander crops: the adverse phenomena have appeared in an unmistakable manner. We have at least good reason to take stock of the situation and seek a safer policy.

5. It must not be supposed that our misgivings are of recent origin: Mr. Wimbush tells me that in 1907 when he first visited Nilambur the management were then exercising their minds over the problem of " diluting " teak crops, and were experimenting with introduction of *Hopea parviflora, inter alia.* Unfortunately it cannot be claimed that we have made great headway. Considerable experiment, directed in several directions, has been in progress,—particularly since the appointment of a Silvicultural Research Officer, and the formation of a Working Plans Circle; but though we have advanced to a point at which an objective has been defined roughly,—namely, by means of an instruction by the Chief Conservator of Forests, stating that in forming new plantations at Nilambur an admixture with the teak is positively *desired,*—our ideas as to the precise type of crop that is our objective have not yet taken very definite shape. While there is uncertainty as to the tree-species that will succeed as artificial crops in mixture with teak, it is premature to speculate regarding financial aspects of mixed teak forestry.

6. It seems likely that we should have advanced much further by this time were it not for a combination of circumstances: for some time we have been able to recognise fairly well the factors that indicate where teak can and cannot be grown: most of the staff have had sufficient training and experience in raising teak plantations, and the growing of teak has presented less difficulties and risks than production of most other species. Teak moreover suffers relatively little damage from deer, etc.: whereas most alternative species that we might otherwise grow successfully are subject to serious damage.

Then, it is still regarded as a truism that production of pure teak plantations must pay best. Of what other species could we hope to sell the young thinnings? Therefore, said a former school of thought, grow pure

teak, and as regards ill-effects of pure teak production,—well, hope for the best! As for the alleged ill-effects: is not Dr. Beeson investigating defoliation and its cure? As for deterioration of the locality after a rotation of pure teak, is the change in the soil chemical or physical? Physical. Very well. Cannot this be put right by such measures as soil aeration? Then is not the deterioration relative, and still somewhat a matter of speculation, and may not the manifestations at Nilambur, described as "disquieting", be attributable to excessive thinning and other faults in detail of management?

Those officers who have had intimate association with Nilambur in recent times have abandoned the stand-point depicted above.

There is strong need, however, to visualise "ideals" for our encouragement. Firstly, must we accept the axiom that pure teak is the most paying crop? Is it inconceivable that financial *advantage*, extending over a succession of rotations, might be secured by growing a mixed crop, in which teak preponderates?

By introduction of the ideal mixture (still to be discovered), we should hope to secure the following advantages: provision of congenial harbourage for bird-life, etc., inimical to defoliators: discouragement of epicormic growth on the teak: maintenance of the forest floor in a condition favourable to volume-increment of the timber crop, and also to the prospects of the ensuing crop to be raised.

8. Regarding the connection between pure crop production and insect pests the following occurs in notes on a tour in Central Europe:—

> "In forestry manuals we find the production of mixed crops advocated as a preventive of damage by insect attacks. In one forest, Puchheim in Austria, I was enquiring regarding the incidence of such troubles: the Director told me that forty to sixty years ago insect pests were of very frequent occurrence and were a most serious matter. In the last forty years or so, the management decided against production of the pure crops that were then in vogue, and did everything they could to introduce mixtures: but it cannot be said that they had the insect pests in view. At the present time, pure crops are few in this region; and it is interesting to learn that insect pests have ceased to afflict the forests to any serious extent, whilst I gathered that adjacent forests, in which pure crops are the rule rather than the exception, are subject to bad insect damage."

Regarding discouragement of epicormic growth: we are already familiar in Nilambur with the improvement effected in this respect, where accident has given the plantation teak trees associates of other tree species.

As regards maintenance of the condition of the forest floor, present-day forestry in Central Europe is suggestive:

The ground condition in areas on which pure crops have been grown is giving trouble, and present methods are a reaction towards the neglected teaching of the old text books: mixture is essential: it does not suffice to grow a mixture of broad-leaved light-demanders,—a species capable of safeguarding soil condition must be present, namely beech, a shade-bearer. Approximately a 10 per cent. admixture of the latter, in an intimate mixture or by small patches, has to be introduced. Not merely in broad-leaved crops, but also in mixed or pure conifer crops a beech admixture is regarded as a safeguard, if not as essential. The contrast in point of ground condition between areas of mixed or pure forest destitute of beech admixture and those in which the beech ingredient is present is quite patent.

It is also held that mixed crops exploit more intensively than pure crops the resources of the soil. Various species make different demands upon the soil constituents. Since the feeding roots of some species have the ability to invade the subsoil more than others, there is, in mixed crops, a probability that the conversion of subsoil to soil takes place with greater rapidity than in pure crops. At the same time, the litter from mixed crops is likely to contain a wide field of constituents.

Czechoslovakian forestry is influenced (no less than Madras forestry), by financial considerations; and, though beechwood is practically unsaleable, their foresters are not satisfied without the beech constituent in practically all their crops. It is unnecessary to labour the application of their views to our problem.

9. I have said above that we have got so far as a pronouncement that "Admixture with our present-day teak crops is desired". It is intended that effect should be given to this pronouncement thus :—Teak continues to be planted at, for example, Nilambur, $6' \times 6'$, and *pure*. Between the teak, root-suckers, seedlings and coppice-shoots of tree-species other than teak appear naturally, in varying profusion. In executing weedings or cleanings it is now to be the Law that labourers must spare these fortuitous ingredients : they may be cut down only at the instance of the District Forest Officer in person. The latter decides which are to be retained as an admixture with the teak crop. We have as yet not had time to appreciate the results of this policy, which is of course a makeshift.

Apart from this newly introduced principle, the application of which may or may not give entire satisfaction, various avenues associated with the problem of teak-growing are being explored. For example, underplanting of various species below teak crops of different ages. Species that are under test are *Hopea*, the broad-leafed mahogany, *Hardwickia pinnata. Mesua ferrea, Hydnocarpus* and *Bambusa arundinacea*. These have given or give promise of various degrees of success. Others with which success has not been secured as yet are *Vateria indica, Filicium decipiens, Pericopsis Mooniana, Trewia, Macaranga, Artocarpus integrifolia* and *Artocarpus hirsuta*. The experiments aim primarily at benefiting existing pure teak crops by improving the ground condition : and the attitude to be adopted in case, for example, *Hopea* proceeds to outgrow the teak crop to be benefited (and this seems imminent in one experimental area), is at present undefined.

10. There is no doubt that useful knowledge is being secured in the course of these researches; though some of it is negative. We have been led to acquaint ourselves with the raising of species with whose silviculture we were unfamiliar. We have little reason to doubt that *Hopea* on lateritic slopes, and mahogany and *Hydnocarpus* on alluvial flats *can* be introduced under teak crops of various ages at a price, say roughly Rs. 12 per acre, $9' \times 9'$ spacing; but the price and the demands upon labour resources, incline us to pause when the question still remains unsettled whether the trees introduced are to be pollarded and kept as a middle-storey, or whether they are to be permitted to join the crown canopy and enjoy special favour in thinnings. We shall no doubt shape our methods when some extensive areas, underplanted by the Nilambur Division, have developed further.

One illustration of a teak crop invaded by natural *Hopea* has already been afforded. The soil condition became admirable; and, the teak having been removed at maturity, the *Hopea* crop (the age of which varies, we believe, up to 40 years), is being permitted to retain possession of the ground. The effect of the *Hopea* invasion was also to clean the teak of epicormics.

The matter of underplanting however is a side-issue of our problem: and experience gained has shaped our future policy to this extent only :—we do not contemplate any extension of underplanting, but will form cheaply in suitable situations, adjacent to young teak crop small patches of *Hopea* or Mahogany, capable of spreading natural regeneration of those species within the teak crops. It has been noteworthy that the more successful examples of underplanting were attained, *not* where it is most needed (in forest destitute of natural undergrowth), but where profuse undergrowth, including evergreen constituents, was present. Without the protection afforded by such undergrowth the young plants failed to stand the exposure to sun, and the baked condition of the soil, during the hot weather, when teak was leafless.

Underplanting research concerns the problem of ameliorating the effects of past pure teak forestry; similarly, research in soil-aeration measures where second rotation crops are being wrestled with: also, soil-aeration

combined with coppicing back of depressing (though fully stocked), second rotation teak crops.

11. We cannot look round with much satisfaction upon experiments in production of teak crops with an even-aged admixture. At Mount Stuart in the Anamalais Hills, a crop was formed in 1927 in which ten lines of teak, $6' \times 6'$, adjoin ten lines of rosewood, and so on. The process is being pursued in 1928, but it cannot be said that the 1927 results are encouraging so far as the rosewood lines are concerned. It would seem as if the latter required ultra-expensive weeding: and that having weeded intensively, fencing would then be needed to afford protection against deer: it is too soon to judge.

12. Should we not in particular be in search of the Indian admixture-species that possesses the special qualities of beech? It matters little whether it is itself a valuable timber provided it has soil-improving qualities and is in some degree a shade-bearer.

Hopea has its climatic limits which do not coincide with those of teak: it tends to outgrow teak too: otherwise it has virtues of soil improvement.

Mahogany is less restricted, climatically, than *Hopea*. It is strongly shade-bearing, also soil-improving, and like *Hopea*, spreads its offspring freely, even under comparatively dense shade. Production of fertile seed appears to commence at an age of 40 years. If,—and of this I am hopeful, but still uncertain,—it will not embarrass us by suppressing its teak neighbours, there seems much to be said for mahogany.

Amongst the few comparative shade-bearers of the Madras dry forest tracts *Schleichera trijuga* suggests itself as a possible "beech substitute".

13. This dissertation will furnish principally evidence of our ignorance, at the present time, of ways and means and prospects in producing "teak crops with an admixture".

A resolution by the Conference to the following effect is suggested: "Recognising that the silvicultural and financial expediency of production of pure teak crops is in doubt, this Conference resolves that, after interchanges with the Imperial Silviculturist of such information as the interested provinces may possess, the Imperial Silviculturist be requested to issue a bulletin on the subject of production of teak crops with an admixture".

14. In conclusion, during 1926 to 1928, revision of Mr. Bourne's 1917 working plan has been completed. During this period the necessity for admixture with teak crops has been apparent to the staff engaged: and the question how to produce mixed crops has never ceased to vex their minds. The plantations themselves furnish evidence that, unless checked by the management, natural admixture appears in the teak crops. So after weighing all other possibilities, the new plan finds no more original solution than the prescription that natural growth of tree-species other than teak shall be protected, and encouraged to persist in the final crop. And this, roughly speaking, was Mr. Bourne's solution, twelve years ago.

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REPORT OF DEBATE.

Mr. Shirley in opening the debate said:

Notes have been received from Madras, Bombay and Burma; and comments from Mr. Newman, Chief Conservator of Forests, Bombay, Mr. Blanford, Conservator of Forests, Burma, and Mr. Robinson, Chief Forest Officer, Coorg.

It is generally agreed that pure teak plantations are undesirable. The chief drawbacks are stated to be damage by defoliators, epicormic branches, fluting and difficulty in regenerating areas which have carried a pure teak crop (Madras); lack of soil protection (Bombay); soil erosion and subsequent burning of the roots of the trees (Burma).

The general opinion is that mixture, either natural or artificial, is the cure for these defects.

Bombay favours natural mixture or wide spacing of the teak in new plantations with the introduction of subsidiary species between the teak; the

latter proposal has not, I gather, been tried. Madras is looking for the Indian beech for introduction into old plantations or for planting with teak. The Indian beech has not yet been found and the final conclusion is that a natural and fortuitous mixture of other species is the best that can be obtained so far.

In Burma the idea of mixtures in new plantations has largely been given up and efforts have been made to underplant existing plantations. The only real success has been obtained with the bamboo, *Cephalostachyum pergracile.*

Mr Robinson, who held charge of the Nilambur Division, considers that a natural undergrowth can be obtained by heavier thinnings and encouraging the undergrowth. He dislikes the introduction of bamboo but it appears that *B. arundinacea* is the only one which has been tried. This bamboo appears to be very difficult to control in young plantations and cannot be killed out before the teak is put in.

Mr. Newman considers that underplanting is unnecessary and would be very expensive because of the necessity for weedings.

Mr. Blanford is not satisfied that mixture of other tree species with teak in new plantations in Burma has really failed and thinks that further efforts should be made. He considers that epicormic branches are mainly due to underthinning and the fluting is due to unsuitable soil or situation and not to the planting of pure teak.

Mr. C. K. Homfray, Silviculturist, Bengal, states that early and heavy thinnings have resulted in an adequate undergrowth of bamboo whereas in the older plantations which were not thinned there is no undergrowth. In Chittagong Hill Tracts mixture is impossible because a very dense canopy is required to kill out *Eupatorium.*

* * * * * * *

Mr. Blanford drew a distinction between mixture in the overwood by individual trees, strips or blocks, and the introduction of undergrowth. The first case dealt with the breaking up of a pure crop with a view to the incidence of insect and fungi pests in pure crops, the second with the protection of soil and improvement of the shape of the trees in the main crop. He personally had not much faith in mixture by strips, blocks or individual trees on the incidence of insect attacks, at any rate of the bee hole borer.

With regard to protection of the soil, he advocated strict fire protection and the encouragement of undergrowth, especially of bamboo. He believed that if a suitable bamboo was chosen, it would be introduced quite early in the life of the plantation, probably after the first thinning. He had recently seen an instance of earlier introduction of bamboo by seed where, under fire protection, the bamboo had developed more rapidly than the teak and had to be cut back. He believed that the correct time to introduce a mixture of a suitable soil improving species was with the formation of the crop, but that previous partial success in the broadcast sowing of accessory species was now nullified in most new Burma teak plantation by the dense growth of *Eupatorium.*

Mr. Champion: In the course of my tours in the provinces where teak plantations have been made, I have noted as my opinion that much of the trouble arose owing to attempts to place teak on unsuitable soils. I do not consider that trouble with *Bambusa arundinacea* is likely over the bulk of the areas being planted, because this species is confined to damp hollows and will not grow vigorously on other soils. I would venture to suggest that in speaking or writing on this subject, it should always be made clear whether a mixture in the canopy or an undergrowth is referred to.

Mr. Minchin: Since there is general agreement that admixture with teak plantation is necessary, I am inclined to reiterate my original resolution, that to avoid repeating experiments that have failed elsewhere the Central Silviculturist should collect information as to attempts that have been made to produce mixed teak plantations and publish them. Mr. Champion mentions lack of clarity as to our object in mixture—to produce as crown mixture or an understorey mixture. I think I shall be representing Madras correctly in stating that most Madras officers find difficulty with the problem

of future management of *crown mixtures;* and are more in favour of the lower storey mixture. We shall certainly try the Burma bamboo *Cephalostachyum pergracile.*

A line that we propose to follow in the present year is sowing, (in the year of teak planting) seed of a few selected species including *Xylia xylocarpa* and *Schleichera* which offer some promise of fulfilling the "beech" functions.

Mr. Newman said that in Bombay complete utilisation in populous districts usually leaves little to burn and it is not only the practice but essential in such cases to collect the rubbish on patches and burn it. These patches only are sown up with teak and the rest of the area is regenerated naturally mainly by coppice. In this way plantations of pure teak are avoided.

The same practice has however,—with the objects (1) of securing a more intense burn; (2) of maintaining a mixture of species and thereby not disturbing to an undue extent the existing character of the forest,—been followed to some extent in forests situated in less populous areas where utilization is anything but complete, and only large timber can be marketed.

The practice as observed hitherto, while involving greater initial expense, does result in securing far better plants on the burnt patches and a far more satisfactory destruction of weed-growth than can be obtained by the light burn resulting from firing thinly scattered slash all over the regeneration area.

Mr. Osmaston (*Bihar*) said that two experiments he had carried out indicated that *Bambusa arundinacea* could be kept in check. He found that by felling and burning this bamboo in the first year and again in the second year, when the tree crop was introduced, the clumps were so weakened that the subsequent shoots could easily be kept under control.

Mr. Robinson (*Coorg*)*:* Mr. Bourne in his Working Plan recommends *Bambusa arundinacea,* but he had no actual experience of it except as isolated clumps in the plantations. Personally as Mr. Shirley has said, I have a horror of *Bambusa arundinacea* in teak plantations. My reasons are that its height growth is so great that it cannot be safely introduced until the teak is 25 to 30 years old, that is, not until the period of maximum height growth is over. Secondly there is the difficulty of getting rid of it at the end of the rotation when we want to be rid of it until our second rotation crop is 25 or 30 years old. Mr. Osmaston's description of work done to get rid of this species of bamboo gives some idea of the expense this operation may entail.

Another difficulty is that of control when seeding occurs, and plantations too young to receive their admixture will be in danger of being swamped, or else tremendous expenditure will have to be incurred. The account of the Burma species with the unpronounceable name sounds most interesting.

I was also very interested to hear Mr. Newman refer to *Xylia* as a possible species to mix with teak and one has read of *pyinkado* in Burma in association with teak. In Nilambur it is most noticeable that as one passes from 1st to 3rd class one meets with more and more *Xylia* and the areas where teak has failed entirely owing to laterite are stocked with almost pure *Xylia.* I think I am right in saying there is no *Xylia* in first class teak areas.

Lastly I notice Mr. Blanford in his note quoted by Mr. Shirley thinks fluting is due to unsuitable soil or situation. This is interesting as at Nilambur it is the first class areas that show the worst fluting.

Mr. Barrington: In Burma we are agreed on the treatment of pure teak plantations. They should be thinned early, often and heavily, undergrowth should be encouraged and even planted if necessary, and fire protection should be the rule. We are not afraid of bamboos because we consider cleanings necessary every year for ten years or more.

We are not agreed on our definition of mixture. Mr. Shirley would concentrate entirely on bamboos undergrowth. Mr. Blanford still favours broadcasting of tree seeds (also a vertical mixture), and I am not yet convinced that mixture in strips (horizontal mixture) can be written off as a failure.

In most of Burma, *Xylia dolabriformis* overtakes teak at an age of 10-15 years, so a mixture by individuals is useless. I tried strips of 30 and 60 feet in Toungoo in 1921 to 1923, and Mr. Blanford agrees that the experiment was ruined by subsequent neglect. I advocate further experiment on those lines, and should leave *Xylia* groups wherever they occur so as to sow up an undergrowth as the trees grow up.

Mr. Shirley said that the ground seemed to have been thoroughly covered by those who had spoken. As regards the patch method in force in Bombay, he remarked that in Burma numerous small and scattered plantations had been made. The trouble was that the encroachment of the natural forest had wiped out hundreds of acres of such plantations. Teak being a very pronounced light demander is soon swamped by weeds and bamboos, and cutting round the edges of small areas makes the costs per acre very high. Mr. Osmaston's method of dealing with *Bambusa arundinacea* under which the tree crop is introduced in the second year would, in Burma, result in a dense mass of weeds which would be almost impossible to control. In Burma it is essential to put in the tree crop immediately after cleaning.

As regards an intimate mixture of other species with teak, it should be noted that the crowns of good teak extend to at least one third and often one half of the total height and as a tree is strong light demander the crown must be fully exposed. The mixture would therefore reduce the volume per acre of teak very considerably. He therefore favoured an understorey especially of bamboo.

As regards Mr. Champion's point that more careful attention should be paid to the soil, he said that, in Burma, third class teak was more valuable than first class timber of most other species and it was therefore preferable to plant teak as far as possible. [Mr. Champion readily agreed that this was very often the case.]

As regards the bee hole borer, a statement had just been received from the Research Officer, Rangoon, which showed that plantation teak contains three times as many holes as natural grown teak. It should be noted, however, that some of the plantation trees came from a plantation of small area now completely surrounded by paddy fields. It did not appear therefore that the spread of this pest would be checked by isolating teak plantations. Further information should be available shortly from the Entomologist, Burma.

ITEM 9.

REGENERATION OF TROPICAL EVERGREEN (RAIN) FOREST.

Papers were contributed by the Central Silviculturist (a general survey, *vide infra*), Mr. Minchin (Madras, *vide* p. 110), and Mr. Rowbotham (Assam, *vide* p. 115), of which the last was not generally circulated beforehand.

An account of experience in Malaya was submitted by Mr. Blanford. (*Vide Indian Forester*, June and July 1929).

Other notes were submitted by Messrs. Newman (Bombay), Rowbotham (Assam), and Robinson (Coorg).

The debate (*cf.* p. 132) was opened by Mr. Minchin (Madras), who reviewed the papers with special reference to the Central Silviculturist's general account and proposals. He also stressed the importance of the recognition of sub-types in the rain forest, as each undoubtedly presents its own individual silvicultural problems, and procedure successful in one can only be applied with the greatest caution in another. Mr. Blanford (Burma) and Mr. Shebbeare (Bengal) also referred to this matter in similar terms. A summary of results obtained for Assam was given by Mr. Rowbotham, and for Coorg by Mr. Robinson. Mr. Blanford pointed out some amendments required in the Central Silviculturist's paper where it concerns Burma,* and referred to what he had recently seen in Malaya. The Chairman closed the debate. The following resolution was passed, having been proposed by Mr. Rowbotham (Assam) and seconded by Mr. Homfray (Bengal).

Resolution 9.

Resolved *that this conference draws the attention of Provinces concerned with tropical evergreen forest to the desirability of solving regeneration problems before proceeding with heavy fellings.*

The conference generally agrees with the proposals for policy and research in the Central Silviculturist's note.

Further, it is recognised that results of evergreen regeneration research work cannot adequately be expressed without reference to the forest sub-types (within the category rainforest or tropical evergreen). Local Silviculturists in consultation with the Central Silviculturist should try to draw up a classification of sub-types.

Paper (*i*)

Contributed by

H. G. Champion, *Silviculturist, Forest Research Institute.*

CONTENTS.

* These amendments have been made as far as possible at present in the paper as reprinted here.

1. Introductory.

There is unfortunately as yet no generally accepted classification of forest types, with standardised nomenclature and definitions, such as would enable one to allot a given forest area to one or other recognised type without further explanation. Every one would probably agree that certain forests were good examples of the type referred to in the title of this note, but many other forests would be included in it by some and excluded by others. In India, we have plenty of classifications, but they are all local, as is apparent from Troup's summary in the Introduction to his "Silviculture of Indian Trees".[1] Tropical evergreen or "rain" forest is generally what is termed a climax formation, and in its typical form, as in the Western Ghats, Assam, and Tenasserim, is readily recognised as such; the difficulty is to draw the line between it and other forms of moist mixed forest which also generally have a large proportion of evergreens, whilst some of their conspicuous species may also be freely met with in unquestionable rain forest, notably some Dipterocarps, *Tetrameles*, etc.

Troup[1] (*loc. cit.* p. xxxiv) drawing on Schimper[2] (*loc. cit.* C. IV., pp. 284-344, especially "Asia" pp. 293-99), describes its main characteristics thus :—"Rain-forest is the evergreen forest characteristic of warm tropical regions with heavy rainfall and high atmospheric humidity. The rainfall is at least 80 inches, but is often much greater. The dry season is usually not prolonged, or where there is a prolonged dry season, this forest occupies moist situations. The vegetation is luxuriant, the forest often consisting of two or more tiers, the trees of the highest tier being at least 100 feet high and often much taller. The species are very numerous and are chiefly or entirely evergreen; gregariousness is strikingly absent. Many of the trees have plank buttresses at the base; they have as a rule comparatively thin smooth bark and are only sparingly branched. The leaves are of very diverse forms, often firm, leathery and glossy, seldom finely pinnate or with a thick covering of hairs. The forest is rich in thick stemmed climbers, climbing palms and woody as well as herbaceous epiphytes."

This description, to which may be added the remarks that bamboos are typically absent or inconspicuous and that cauliflory is common, gives a fair idea of the type of vegetation in question, but again gives no lower limit for the next type contrasted with it is the predominantly deciduous monsoon forest with a marked dry season. Intermediate forms find mention in some accounts such as the "wet mixed forest" of some Bengal Working Plans[3], and the "sub-evergreen" in Tenasserim[4], but these appear to be inferior types compared with the rain forest proper, and it is suggested that they are of recent origin due directly or indirectly to human interference (*taungya*, fire protection, etc.). This leads to the view that they may themselves be only transitory and may ultimately progress or revert to forms more like the true rain forest. With ascending altitudes in the hills, tropical evergreen merges into sub-tropical and temperate evergreen forests beginning at 2,500 feet to 3.500 feet according to latitude and other local factors. The great height of the trees of lower elevations is lost and the constituent species are different, *Cupuliferae* (*Quercus and Castanopsis*), *Schima*, *Eurya*, and some of the smaller bamboos being particularly characteristic, though *Lauraceae*, *Eugenia*, and *Magnoliaceae* are equally typical of both.

In this note, unless it is stated to the contrary, only the pronounced tropical evergreen or rain forest is under discussion.

Whilst primarily a climatic climax, rain forest is not entirely independent of edaphic or soil conditions, and under identical climate, parts of a forest tract which is mainly evergreen, may be definitely mixed decidous. This can usually be traced to soil and exposure differences, and is the more frequent the nearer climatic conditions are to the lower limit permitting development of rain forest. Even well within the limits, there may be considerable variety, at least in hilly country, and one cannot say that any one type is the climax for the whole area as has been pointed out in Shreve's[5] study of the rain forest of the West Indies (*loc. cit.* p. 106). In most areas where rain forest is found, there will be low lying strips where a rather

different flora prevails, the genus *Lagerstroemia* being particularly typical. This riverain forest—as also the allied freshwater swamp form—is usually easily recognised though much mixed up with the other.

2. The Synecology of Rain Forest.

It is obvious that the conditions of life in such forests are very different indeed from those prevailing in the opener, more xerophytic types which occupy the greatest area in India and the world generally. Although the more precise nature of the differences and their extent and significance has been made the subject of special studies in several countries, we still know very little about it.

It may be noted that the intensity of the light in the middle canopy is about $\frac{1}{25}$ of the full incidence, whilst on the ground it is only $\frac{1}{440}$ (Allee[6]). Relative transpiration seems to be about the same for the plants grown in the shade as for all other vegetation, but as the atmosphere is constantly humid, the absolute transpiration is low.

Considering the regeneration of the important timber tree species, perhaps the most influential feature is the range of conditions it must pass through from the germinating seed lying on a thick layer of rotting vegetation in a nearly saturated atmosphere with the weakest of light, *viâ* the small seedling competing with herbs and creeping shrubs still in deep shade and with abundant mixture, *viâ* the pole or sapling fighting its way into the middle canopy with rather less humid atmosphere, but more light, to the top canopy where it is exposed to the sun of the tropics and winds which may be relatively dry. Conditions may be decidedly xerophytic in the top storey, as is indicated by the nature of the foliage and the fact that very many top storey species are more or less deciduous. The studies quoted have not unnaturally been made mainly on the lower strata of vegetation, the giants of the forests almost defying investigation on ordinary lines, but not a few features are common to all strata. Thus it appears that the rain forest is very little dependent on the soil, which may be shallow even to an extreme, and when exposed to light and air, what we should call a very poor one; the forest has apparently evolved a system of living largely on the products of its own decay (McLean[7]). Though the soil underlying many of our forests is undoubtedly good, it may be remarked in most, how the trees spread over the rocky outcrops which get re-exposed very rapidly on destruction of the continuity of the canopy.

3. Distribution of Tropical Evergreen Forest.

It has been seen that the distribution depends primarily on the two factors of temperature and rainfall. Temperature requirements are fulfilled throughout the tropics up to an altitude of 2—4,000 feet according to latitude, and in considerable areas outside the actual tropics. The rainfall necessary for its development is not only considerable, but must be well distributed, for there are many districts where the annual fall is well over the quoted 80 inches, but where the vegetation remains of the typical deciduous or monsoon types, and is associated with a period of deficient moisture. The greater the rainfall, the more dominant the evergreen type becomes, and few areas with over 125 inches reasonably distributed are without it. The nearer the equator and the higher the mean temperature, the shorter the dry interval which will inhibit the development of the typical evergreen forest. On the other hand, where the rainfall or its distribution are near the limiting figures, situations favourable to the retention of moisture such as sheltered hollows and damp stream banks, also favour the development of this type, in fact in the plains forests of North Bengal, much of Burma and elsewhere, it is confined to such places. Prevalence of fog increasing humidity and reducing insolation may permit the development of rain forest with a much smaller rainfall (even down to 44 inches near Rio-de-Janeiro[7]).

Extensive rain forests are met with in the Amazon basin and adjoining parts of South and Central America, the West Indies, the West Coast of Africa, the West Coast of India, and a big tract of South-East Asia, including the Philippines where upwards of 75 per cent. of the forest area and 95 per cent. of the timber is of this type.

In India, it is well developed on the West Coast and in the moister parts of Burma, in Chittagong, Arakan, the Andamans, and the Eastern Sub-Himalayan tract and lower hills, showing on the map an outline very similar to that of the over 90 inches rainfall areas excluding the higher hills. It will be noticed that Madras, Bombay, Bengal, Assam, Burma and the Andamans—well over half the major provinces, come into contact with the evergreen problem. We shall have occasion to refer to the following six regions irrespective of political boundaries:—

(*i*) West Coast.
(*ii*) E. Himalaya (North Bengal and N.-W. Assam).
(*iii*) S. Assam (Sylhet, Cachar).
(*iv*) Chittagong and Arakan.
(*v*) Burma and Upper Assam.
(*vi*) Andamans.

It might be preferred to distinguish the Upper Burma and Assam occurrence from the Southern Burma and Andamans, but it is convenient to deal with the Andamans separately, and Upper and Lower Burma are then best taken together.*

4. Composition.

The general characters of rain forest have been given above, and a few further notes are required as to the actual composition in the Indian and Burma examples. The Dipterocarps are undoubtedly the most striking feature, especially the genus *Dipterocarpus* (*vide* Troup[1], p. 32) though several species are actually more or less deciduous, and extend freely into the moist deciduous types. The West Coast has only one species, *Dipterocarpus indicus*, which does not occur elsewhere, and there are none in the East Himalayan area, but the immense height to which they attain and their strikingly fine boles attract attention wherever they occur. Important also is *Hopea* with closely allied species in Burma and the West Coast. The several Dipterocarps tend to be social, and their presence or absence on any spot is very hard to explain. The *Leguminosae* are much less well represented than in Africa and the New World.

Calophyllum (in closely allied species) and *Mesua ferrea* are important timber trees met with practically everywhere in the evergreen forests of India though varying greatly in frequency. *Artocarpus* in several species is again very characteristic, *A. Lakoocha* occurring in all 6 regions, *A. hirsuta* and *A. integrifolia* belonging to the West Coast, and *A. Chaplasha* being absent only from the last mentioned area. Other well-known trees frequently met with in all our evergreen forests are *Sterculea alata*, *Acrocarpus* and *Tetrameles*, *Cedrela Toona*, and *Chickrassia*, all tending to be more or less deciduous, and the first three reaching immense size with strikingly developed plank buttresses. *Eugenia* spp., *Mangifera*, *Diospyros*, *Myristica* spp., and *Myrtaceae* are also very generally common evergreens, whilst such trees as *Bischofia* and *Lagerstroemia Flos-Reginae*, which characterise wet soils, also occur throughout. Not a few species tend to be confined to the more southern parts, the West Coast and Burma, such as *Antiaris* and *Holigarna*.

The great richness of species is a pronounced feature of tropical evergreen forests and one of considerable practical importance, for it results in the scattering of any given species by single trees or groups over a wide area, and this means difficulties and waste in working unless markets are

* This opinion was not shared by the Burma Officers present at the Conference; they held that the Upper and Southern Burma types were quite different.

available simultaneously for a large variety of species. How complex is the flora may be illustrated by the following average figures per 100 acres collected for a fairly typical area in Coorg (Tireman[15], p. 18) for trees over $6\frac{3}{4}$ feet girth only. Lists from Madras are very similar.

	%		%
Vateria	26=9·1	*Acrocarpus*	2=0·8
Hardwickia	23=8·0	*Mesua*	2=0·7
Dipterocarpus indicus	14=5·0	*Mangifera*	1=0·5
Dichopsis	$6\frac{1}{2}$=2·3	*Eugenia*	1=0·5
Hopea	6=2·2	*Artocarpus hirsuta*	1=0·5
Calophyllum	$5\frac{1}{2}$=2·0	*Diospyros*	1=0·4
Bombax	3=1·0	*Dysoxylum*	1=0·3
Cedrela	3=1·0	*Artocarpus integrifolia*	1=0·3
		Tetrameles	1=0·3

Another list is from Kalainaung Reserve, Tavoy (Kin and Zuiba blocks).

Species.	12" to 24" diameter	24' and over	Total.	Per cent.
Eugenia grandis, etc.	122	40	162	6·5
*Swintonia floribunda	46	88	134	5·4
*Lagerstroemia spp.	50	44	94	3·7
*Anisoptera, Parashorea and Shorea spp.	38	55	93	3·7
*Pentace burmanica & Griffithii	65	25	90	3·6
Dillenia spp.	71	14	85	3·4
*Hopea odorata & spp.	44	31	75	3·0
Schima spp.	31	8	39	1·5
*Dipterocarpus spp.	18	20	39	1·5
Dysoxylum spp.	28	4	32	1·3
Cinnamomum inunctum	7	10	17	·7
Xylia dolabriformis	12	5	17	·7
Vitex spp.	13	2	15	·6
Altingia excelsa	3	4	7	·3
*Michelia & Talauma spp.	4	3	7	·3
*Artocarpus calophylla	1	3	4	·1
Lophopetalum fimbriatum	2	1	3	·1
All others	1294	296	1590	63·6
				100·0

5. Local Forms.

Whilst great similarities in general facies and ecological conditions, and not a few characteristic species (or better still, genera or subgenera) are met with wherever the type occurs, each of the 6 more or less disconnected areas distinguished above shows certain features and trees peculiar to itself, or at least shared only with some of others. Variations in local conditions, mainly connected with the stage of "opening up" of the country reached in each case, also result in the forestry problems bearing somewhat different aspects from place to place.

(i) *The West Coast.*

The West Coast forest flora[15] [16], though presenting as we have seen many features in common with the other areas, differs considerably more from them than they do among themselves, a fact which may well be traced to their different geological history and relative isolation. Dipterocarps are local, *Hopea parviflora, Dipterocarpus indicus* and *Vateria indica* being the chief, *Mesua, Hardwickia pinnata, Calophyllum* and *Artocarpus* are the chief timbers of better quality, whilst *Acrocarpus, Dysoxylum malabaricum, Polyalthia* and *Elaeocarpus* may be mentioned among saleable soft woods,

*Top storey species are marked with an asterisk.

with *Cullenia* and *Dichopsis* as of small value but often abundant. Compared with the other evergreen forests, those of the Western Ghats are perhaps not so infested with cane brake though climbers and epiphytes are abundant enough, and they have been very severely reduced in extent and quality by shifting cultivation and other agencies, as will be discussed later. Gregarious patches of "eta" reed (*Ochlandra* spp.) are a special feature in the south: their occurrence and origin require study.

(ii) *The Eastern Himalayan Area*[3] [17].

It is questionable whether Upper Bengal and the adjoining parts of Assam have any true tropical evergreen forest, and in any case, it is restricted to favourable spots scattered among the mixed deciduous forests. There is evidence that considerable changes have taken, and are taking place in this area, and it is possible that the true climatic climax is tropical evergreen over a large area than is at present apparent. Dipterocarps are absent, the chief species being *Æsculus, Eugenia, Artocarpus Chaplasha, Cinnamomum cecidodaphne, Talauma, Echinocarpus, and Duabanga.* Much of the area of heaviest rainfall is in the hills, and though mainly under evergreen, the forest is of the temperate form with oaks and *Castanopsis* predominating. There is no marked break between this area and Upper Assam, but the latter appears more closely allied to the Burma region.

(iii) *S. Assam (Sylhet and Cachar*[18]).

This area lies round the Khasya and Garo Hills being virtually continuous with the Chittagong Tracts, but partly separated from Upper Assam by a belt of less rainfall to the lee of the hills.

The important trees are *Mesua, Artocarpus Chaplasha, Michelia Champaca, Cinnamomum cecidodaphne, Aquilaria Agallocha, Dipterocarpus turbinatus, Talauma, Calophyllum, Kayea,* etc. There is relatively little cane or palms and climbers, but ephiphytes are very numerous.

(iv) *Chittagong and Arakan.*

This is a strip running down the Arakan Coast from the Ganges to the Irawaddy delta; it is continuous with the Sylhet area, but is separated from the Eastern evergreen tract of Burma by the region of less rainfall east of the Yomas. As expected, the chief trees[19] [20] are very similar to those of Central Assam, but several species of *Dipterocarpus* ("*garjan*") become conspicuous, as well as other species more typical of the South-East. The chief species in the Arakan forests is *Buchanania lancifolia, Mangifera sylvatica* being also common. *Hopea* occurs rarely, and the occurrence of *Dipterocarpus tuberculatus* (*in*), which is not associated with evergreen forests in other parts of Burma, is noteworthy. The *garjan* may form nearly pure forests which are not then included in our tropical evergreen type. This area, too, has been very greatly altered by shifting cultivation.

(v) *Burma and Upper Assam.**

The Burma area[13] is by far the largest continuous area of tropical evergreen forest we have and is itself only the northern part of the big tract taking in all the Eastern side of the Western Peninsula down to Singapore. *Dipterocarpus spp., Hopea odorata* and *Parashorea stellata, Anisoptera* and *Shorea assamica* (the last in the North only) are the chief Dipterocarps, associated trees of the top storey being *Sterculia alata, Tetrameles, Acrocarpus. Pentace,* etc., whilst *Artocarpus Chaplasha, Albizzia lucida* and *Mangifera* must be mentioned. *Pentace, Parashorea* (in the South only) and *Shorea assamica* are examples of conspicuous trees not met with outside

* See Footnote on p. 94.

this area. A very valuable study of the type from the forester's point of view has recently appeared in H. C. Smith's Working Plan for a part of South Tenassrim[4].

Stamp[14] separates the southern form under the title "Evergreen Dipterocarp forest," from the northern "wet evergreen (Northern) type;" on the grounds of the absence in the latter of many of the typical Dipterocarps (*e.g.*, *Anisoptera*, *Parashorea*) and the relative prevalence of *Meliaceae*, *Michelia*, etc., and *Dendrocalamus Hamiltonii*.

(vi) *Andamans.*

The evergreen forests of the Andamans[20] are generally similar to those of Lower Burma, especially those of Tenasserim. They tend to be confined to the ridges and upper slopes of the hills and a micaceous sandstone favours their growth more than other soils do. There is a dense undergrowth of canes, including the climbing bamboo, *Dinochloa andamanica*, in fact these forests probably include the densest we have (Rodger[21]). There appears to be a number of species peculiar to the islands, including some of the more conspicuous such as *Planchonia andamanica* and *Garcinia andamanica*, but as our knowledge of Tenasserim increases, it appears likely that the number of these will be reduced. The better known examples of *Terminalia Manii* and *Terminalia bialata* do not belong to the evergreen forest.

6. Destructive Agencies, Past and Present.

The first time one encounters tropical evergreen forest it appears unconquerable. On longer acquaintance, one learns that not only is it quite vulnerable, but that its extent has already been enormously reduced, and its facies very greatly influenced by human activities. The large areas cleared for rubber, coffee, etc., are obvious, but a far greater proportion has been destroyed or altered beyond recognition by shifting cultivation, the most striking examples being perhaps the northern end of the Western Ghats[22], and the hill tracts between Assam and Burma. So extensive have been these operations and so long have they been in action, that it is not always easy in many cases to be sure whether the existing forest is of the type that originally occupied the ground or not, for although a small clearing is very soon swallowed up by the evergreen forest on being abandoned, the process for extensive clearings is most certainly a very slow one of long, but quite unknown duration (Smith[1], p. 39).

Areas that are taken up for permanent cultivation of any kind cease to be forest, and no longer directly interest us, but all other forms of utilisation or destruction bearing on the evergreen forest, which leave the area still actually or potentially forest, require close study. Among these may be enumerated :—

1. Timber fellings concentrated on one or few species.
2. Heavy logging operations.
3. Long-interval jhuming.
4. Short-interval jhuming.
5. Lopping, grazing, burning, etc.

A possible sixth agency would be progressive climatic changes.

7. Residual Areas.

It is impossible to give figures with any pretence to accuracy for the areas still under primary tropical evergreen forest in the six regions recognised. Even had all our forest divisions been adequately stock mapped, there would still remain the large areas belonging to private owners and in the Indian States (notably Travancore).

The nearest approach to such an estimate in square miles which is available is:—

Region.	Province or State.	Government.	Private.	Total.
(i) *Western Coast*	Bombay	325	...	325
	Madras	2,060	1,200	3,260
	Coorg	300	...	300
	Travancore	718	...	718
	Mysore	567	440	1,007
	TOTAL	3,970	1,640	5,610
(ii) *Eastern Himalaya*	Bengal Assam	50	...	50
	TOTAL	50	...	50
(iii) *Southern Assam**	Cachar	948	..	948
	TOTAL	948	...	948
(iv) *Chittagong and Arakan*	Bengal	40	...	40
	Burma†	1,000	...	1,000
	TOTAL	1,040	...	1,040
(v) *Burma and Upper Assam*	Burma‡	14,000	...	14,000
	Assam§	2,220	220	2,440
	TOTAL	16,220	220	16,440
(vi) *Andamans*	Andamans	1,000	...	1,000
	TOTAL	1,000	...	1,000
	GRAND TOTAL	23,228	1,860	24,088

8. Natural Regeneration.

In some ways, the conditions under which tropical rain-forest grows are optimum for plant development. The two factors on which most depends are warmth and adequate moisture supplies, and these, as well as light incidence per square foot, are all highly favourable. True the tallest and biggest trees on record are not found in this type, but in the more temperate coniferous forests of North America and in the Eucalyptus forests of Australia, but trees magnificent in height, girth and bole are a feature, and the total amount of vegetation per acre is undoubtedly much greater. Possibly the superiority of the *Sequoias* and *Eucalyptus* may be connected with a stronger transpiration current due to less humid air and abundant subsoil water supply, or to rather better soil conditions.

On the other hand, the internecine struggle for existence is at its very greatest, and a high degree of co-ordination to the very special factors of the environment is essential if a given tree or tree species is to propagate its kind. Once in the main canopy, a tree has only an occasional lightning stroke or cyclone to fear, and escaping these, usually lives till old age ultimately weakens its vitality to such an extent, that fungi and similar agencies can no longer be resisted. True there is a chance of getting smothered or weighed down to the breaking point by climbers, but this

Notes.—* A part of the evergreen of the Sibsagar and Nowgong divisions might be added by transference from (v).

† Mostly unclassed forest.

‡ Provisional and very rough estimate.

§ See note under (iii) above.

rarely happens to the top storey trees. But to reach and keep a place in the main canopy is an end exceedingly difficult to accomplish.

'The commonest starting point is to produce large quantities of rather heavy seed which fall to the ground near the mother trees and germinate with a considerable supply of nutriment available to them—moisture being abundant enough, but space in the soil, and light for carbon assimilation being both very deficient. The seedlings must be able to persist even if they do not grow, at least long enough to be replaced by others. In some, (*Dipterocarpus turbinatus, Artocarpus Chaplasha*) the powers of persistence are great, and the seedling very gradually forces its way upwards, though still with little hope unless chance happenings give it more light. A place in the sun is only attainable (for trees—climbers have other ways of getting it) when through the agency of old age, of the weight of climbers pulling down a tree or stripping its branches, or of lightning, cyclone or man, a break is made in the canopy, and then the race is to the swift and the strong. Only under a fortuitous combination of favourable circumstances particularly as regards season, would new growth from fallen seeds stand a chance against pre-existing seedlings. In so far as it is not invaded by creepers, the gap will first be filled by those seedlings which have the greatest powers of withstanding shade without thereby losing the power to respond at once and beyond others to the inrush of light. There will be a desperate struggle for life and room even within a few months and it will continue without loss in intensity till the spot is no longer recognisable as ever having been such a gap: perhaps three trees were removed from the canopy and probably 3, at most 5 or 6 again occupy the space, though during the process described they may not be the first to have topped their neighbours.

We should accordingly expect that among the bigger trees, the commoner species would at all times be represented fairly freely in the lower strata. The question of the regeneration of these forests has been particularly studied in Cachar (Owden[23]), and in the logging areas in Coorg and Madras, and the outcome bears out the suggestion just made, *i.e.*, that there is as rule plenty of small regeneration of the most important species, but that middle size plants are rare except in and around chance gaps.

In Cachar, specimen trees of 26 species are under observation, and in practically every case plenty of seedlings can be found; representative species which may be mentioned are *Dipterocarpus turbinatus, Artocarpus Chaplasha*, and *Podocarpus neriifolia*. In the Karian Shola, Madras, there is no shortage of seedlings of *Hopea* near seed trees, whilst *Mesua* seedlings are scattered throughout. At Chenat Nair (Madras) a strip of 4·4 acres enumerated in December, 1923, showed the following surprisingly large numbers per acre:—

	Seedlings up to 9' girth.	Small trees.
Cullenia	2,620	17
Dichopsis	2,610	28
Dysoxylum	1,940	83
Diospyros	326	1
Myristica	133	2
Garcinia	115	40
Holigarna	115	...
Calophyllum	93	3
Mesua	85	...
Hemicyclia	68	32
Hopea	1	...
Miscellaneous	1,150	72
	8,256	278

Another 14 acres enumerated for all seedlings (mostly quite small) under 9 inches girth showed per acre 58 *Mesua* and 39 *Calophyllum*, 1,210 *Dichopsis*, 955 *Cullenia*, 800 *Dysoxylum*, 207 *Diospyros*, etc., though these

figures are certainly above the average. Similarly at Makut in Coorg, seedlings of the 3 chief species, *Dipterocarpus indicus*, *Calophyllum* and *Hardwickia*, can generally be found in fair numbers, and the first and *Hopea* sometimes in dense patches. *Hopea* in Jalsur East (South Mangalore) was sufficient to permit of conversion of over 100 acres to a virtually pure crop. At Papanasam in Tinnevelly seedling regeneration of *Hopea* and *Balanocarpus* is good, whilst seedlings of *Filicium*, *Nephelium*, etc., are extraordinarily abundant.

Areas that have been less intensively studied are doubtlessly similar in this respect, so that it may be taken that small seedling regeneration of all the species adequately represented in the existing crop is present in reasonable quantity, but that poles and saplings, and all age classes up to attainment of full height will be relatively deficient in all unworked forests of this type. It must, however, be noted that in Tenasserim things seem to be rather different (Smith[1], p. 21), for seedling regeneration is reported to be at least not abundant, though sometimes dense crops of young saplings occur; small gaps appear to fill up quickly, but larger ones due to windfall or exploitation are rapidly occupied by an impenetrable mass of creepers through which the forest trees appear to be unable to grow.

9. Changes following clearing or heavy Fellings.

As has been stated above, Nature's method of regenerating these evergreen forests is a very gradual and inconspicuous one. Small gaps in the mature or overmature overcrop arise, extending over the space occupied by say 2 or 3 full-grown trees—perhaps 50-60 feet across—and from among the thousands of smaller plants and tree seedlings existing in them, a certain number get up and cover the ground once more. This regeneration thus arises from plants which have started life under a dense shade and have persisted under it for varying lengths of time, and it comes up with a good deal of side shade and protection from excessive insolation, and from a dry atmosphere. In any case the surrounding dense forest prevents any appreciable drying out of the soil in the biggest gaps likely to occur.

The opposite extreme is clear-felling of areas of appreciable size, and from what has been said, it would not be surprising if the very different conditions prevailing were totally unsuited to the development of the pre-existing seedlings. I know of no recorded example where the result of simple clear-felling has been followed for any length of time, though a 25 acre plot at Makut, Coorg was girdled in 1919 and then left untouched, and some plots have recently been started in Madras. The progress of events in heavily logged areas suggests clearly enough what to expect. Examples of this are to be seen in several places on the West Coast, notably Makut and Chenat Nair, where such operations were begun about 1920. These areas present two factors compared with the clear-felling which are more favourable to regrowth with the same evergreen type, in that at least some shelter is provided by the unfelled inferior species, and some seed trees of the better species are left intentionally or as unfit to fell. The most striking feature in the few years that have elapsed since the fellings at Chenat Nair is the occupation of the ground by quick growing soft-wooded species often deciduous, such as *Trema*, *Macaranga*, *Callicarpa*, *Erythrina*, *Acrocarpus*, etc., and the failure of small plants of the more valuable species, particularly *Mesua*, to respond quickly to the increased light and space. Another noticeable point is that rocky outcrops which were completely covered over by the crowns of the trees and a layer of soil and ground vegetation, are laid bare. The general indications are that the evergreen forest will be replaced by a shortlived deciduous less tropophytic type which will very gradually give way to evergreen once more. but evergreen probably poorer in the best species than the original. Chenat Nair evergreen forests are a good deal intermingled with the mixed deciduous type, being near the eastern limit of the wet coastal strip. Makut on the contrary is in the heart of it, and conditions are rather different. The first fellings were perhaps less drastic and the chief species—*Dipterocarpus indicus* and *Hopea*—better adapted to the change, and the felling areas bid fair to become in time

restocked with a more valuable forest than was felled—but much assistance has been given as will be described later. The more usual history of the felled evergreen forest area is that all that will burn, is burnt, and agricultural crops are sown on the rich ash-manured soil which is then cultivated for a longer or shorter period. Crops are taken off for 1, 2 or rarely more years till the richness is lost by removal as crops or by leaching and erosion, and then the area is abandoned once more. Under natural conditions, the evergreen forest is never exposed to fire, cannot be fired in fact, so that trees have no need to be, and actually are not resistant to fire injury[21]. Further, every endeavour is made to get as severe a fire as possible in order to get a clean burn such that the agricultural crops will have little to fear from coppice shoots and weed growth. Such treatment naturally annihilates practically the whole of the original forest except for a few big trees too troublesome to fell, and it leaves an exposed altered soil unsuitable for re-establishment from seed of many of the original typical species, even if the seed reaches the area. Where these practices prevail on hilly ground—and much of the evergreen zone is such—extensive erosion is also common. This procedure has completely altered the vegetation over large areas, so much so that it is not easy to reconstruct the original limits of the tropical evergreen type. It has been suggested with good reason that much of the vast areas mainly under the bamboo *Melocanna* in the Chittagong-Arakan regions were once evergreen forest; whilst in Bombay a very degenerated evergreen scrub is all that is left over large areas. From what can be seen in India and in other countries (Chipp[11], p. 60), it is evident that if such areas are left to themselves once more, there is a gradual return towards the climax, but whether it is ever reached, and if it is, how long the process takes, is known to none. In South Tenasserim, all the " giant evergreen " forest below 500 feet has been destroyed by shifting cultivation and its place taken partly by a " sub-evergreen " type with or without bamboos. When the latter are present, there is no distinguishing line between this and moist deciduous forest thus indicating the usual tendency towards the drier type. When bamboos are absent, there is a dense mass of canes, etc., and if nothing is done, " it is likely to be hundred of years before a full tree crop is restored " (Smith[1], p. 39). Further south, however, there are large areas of virgin forest over the lower ground also which should be suitable for *taungya* operations if it does not ultimately become more valuable for permanent cultivation. In South America, McLean[7] has commented on the " failure of the forest to regenerate quickly on *large* cleared areas," and suggests that " the change brought about by clearance is probably largely due to the drying out of the humus colloids and the killing off of the microflora," or " where the rainfall is exceptionally heavy, to the bodily removal of the soil or its nutritive contents by the rain when once the protective leafy cover is cleared off ".

10. Selection Fellings.

With the evergreen, as with the mixed deciduous forests, it has often happened that only one or two species of the scores available are in any demand, so that fellings are concentrated on these, the remainder being left standing. Good examples of this are *Mesua* in Assam, and *Calophyllum* and *Hopea* in the Ghats. With the development of markets, a further series of species is coming into demand notably the soft Dipterocarps, *Dysoxylum*, *Terminalia myriocarpa*, etc., whilst the supplies of the longer appreciated timbers have dwindled. A knowledge of the results of these older fellings would be valuable, but few convincing records exist. The small reserve of Jokai (6 square miles) in Assam near Dibrugarh, was brought under a Working Plan in 1910, mainly with reference to its *Mesua*, after fellings under a 7 feet girth limit had removed all the big trees. Here enumerations over the best 700 acres showed $\frac{1}{4}$, $2\frac{1}{2}$ and 11 trees per acre of girth classes over 6 feet, 4—6 feet and 2—4 feet respectively, with relatively plenty of still smaller stems; but this can hardly be considered good stocking, and it looks as if the species was at best maintaining its position. In any case, however, much of this area is hardly typical rain forest.

In the absence of information from plots under regular observation, the matter may be considered on general lines. It has been seen above that as a rule regeneration of the important species is commonly plentiful and often tends to come up freely close to, if not under, the parent trees. When the latter are felled it is therefore likely that regeneration of the same species is well represented relatively to its competitors, and therefore has a greater chance of occupying the gaps formed by the fellings. The Dipterocarps, especially *Dipterocarpus turbinatus* and *Hopea*, are good examples of this, whilst *Mesua* regeneration tends to be more scattered. There will, however, always be cases where the gaps are seized by other species, particularly if the gap is small and readily covered in by the surrounding already well established trees, so ground must be lost in the long run, but the semi-gregarious habit of the Dipterocarps may possibly be traceable to the general success of the method.

Another point that is perhaps not always realised, is that when a girth limit of say 7 feet is fixed for felling, one is usually felling a large amount of overmature stock representing perhaps twice or thrice any ordinary rotation age, and it is not to be expected that the next lower class, say 6—7 feet can rapidly replace the trees removed, even if it is present in normal quantity as seems rarely to be the case. This is so apart from the fact that the girth increment of many of these tree species is commonly not as rapid as supposed. particularly for the hard woods. A girth of six feet in 90 years has been estimated for *Mesua* in Assam, and *Dipterocarpus* species in Cox's Bazar grow about 1 inch girth a year up to 10 feet.

Finally, the removal of most of the seed trees results in a great reduction in the chances of the selected species gaining a place in the chance gaps which Nature provides

It thus appears that selection fellings concentrated on few species, if no special measures are taken, must result in a steady if slow reduction in the proportionate representation of those species, and that after first fellings the number of exploitable trees per acre must show a great falling off never to be regained.

11. Improvement Works for Natural Regeneration.

In considering the attempts which have been made to maintain or increase the proportion of the more valuable species in these forests, it is most convenient to deal with several areas separately.

(i) *The West Coast.*

Bombay.—Attention at present seems to be concentrated on the mixed deciduous forests with teak, and working plans have little to say about the evergreen forests.

Coorg.—The forests near Makut were brought under a Working Plan by Mr. Tireman[15] in 1916 and this appears to be the first Indian Working Plan dealing primarily with evergreen forest. Selection fellings on a diameter limit were prescribed leaving seed trees as required and also one-third of the total number of exploitable trees; improvement fellings favouring the better species were to be made over 1,200 acres annually, and were to be followed by cleanings to be done as found necessary, but estimated to be needed annually for the first three years and then triennially. Though the area figures have not been worked up to for various reasons, quite enough has been done to show that promising results are possible. Thus in the Urti coupe of 100 acres, felled in 1921-22 and cleaned in 1925 with the removal of all the overwood except 5-10 seed trees per acre, saplings of *Hopea* and *Vateria* are abundant and can be expected to look after themselves with at most one more cleaning; round some of the old trees, the *Hopea* regeneration is magnificent.

A series of experimental plots was laid down in 1919 (by Mr. Ayyar) to follow the effects of varying manipulation of the upper and middle canopy; a heavy opening of the upper canopy with cleanings, as just described, was

found to be the most satisfactory procedure, *Mesua, Calophyllum, Dipterocarpus* and *Hopea* seedlings having grown to 10 feet to 12 feet by 1926.

Mangalore.—Jalsur East, apparently a transition from the typical evergreen type to mixed deciduous with *Hopea* well represented, is one of the finest results of work of the kind obtained hitherto. Fellings began in 1916, small *Hopea* regeneration being present. In the course of the next few years the rest of the overcrop was removed, much by girdling. Frequent cleanings and weedings (which are said to have cost Rs. 12-9-8 per acre up to 1927) have been done to keep down the evergreen shrub growth which tends to outgrow the *Hopea*. *Hopea* saplings are now found all over the area with a height of 4 feet to 15 feet, rarely 20 feet, forming virtually an even-aged pure crop.

Chenat Nair.—The effect of cutting the undergrowth up to various heights, and of soil working before felling were brought under systematic observations in 1921 (Experimental Plots 20—24). The development of pre-existing regeneration in the logged areas of 1923 is also being watched with cleanings as necessary: so far, it would appear that locally a fair proportion of useful species will grow up, but the best species will be poorly represented, and parts will be completely changed in character for a generation or more. Small regeneration was plentiful enough originally. It is found that seedlings should not be suddenly exposed by over heavy weedings. One hundred individual seedlings of *Dichopsis, Calophyllum, Mesua, Cullenia* are under observation since 1921 (Experimental Plot 26). A recent report is not available, but after 3 seasons results were rather inconclusive. Cutting the low shrubs only made little difference in the mortality or growth, and *Calophyllum* is definitely helped by lightening the upper canopy layers.

Mt. Stuart—(Karian Shola).—A fine block of almost 3,000 acres of virtually unworked forest with fine *Hopea, Mesua*, etc. Cleanings have been done at about Rs. 3 per acre to help the existing small regeneration of these species which appear somewhat slow to respond when the upper canopy remains intact. Experimental plots have been laid down to follow the effect of varying manipulation of the canopy and weedings, but at present they appear a mass of *Strobilanthus*.

Tinnevelly (Papanasam).—For over 20 years now[25], cleanings have been done to help *Hopea* and *Balanocarpus*, mainly by girdling inferior species and hollow mother trees over the abundant regeneration; the results are promising on the whole and groups of good young poles, so unusual a sight in the tropical rain forest, are frequently encountered.

Travancore.—No accounts of work in Travancore have been traced, if any exist.

(ii) *Eastern Himalaya.*

Very little is on record with regard to the limited evergreen forests of Northern Bengal, Assam and the foothills. The *taungya* system is so well established and successful in the mixed deciduous forest that natural regeneration of the relatively scattered patches of evergreen as a special problem is unlikely to be attempted for some time, though small areas of this and much of the " wet mixed type " are included in the yearly coupes.

(iii) *Central Assam.*

As far as is known to the writer, systematic operations to favour regeneration have not hitherto been made, but useful information has been collected for over a score of species on natural regeneration round mother trees with some help from cleanings, demonstrating that such work can give very useful results. It is understood that the working plans under compilation for Cachar[33] and the Upper Brahmaputra forests will prescribe such work.

(iv) *Chittagong and Arakan.*

In *Chittagong*, the evergreen forests, as we have seen, are much mixed with the " wet mixed " and ' *garjan* ' (*Dipterocarpus* spp.) forests. Very little virgin forest is left, and most of the area one would expect to carry rain forest had been jhumed at one time or another. The pure *garjan* may

also be largely a secondary type. Under the Working Plans, natural regeneration (which is plentiful) will be relied on for the *garjan* whilst the *taungya* method is being established for the other types. Cultural operations do not appear to have been tried at least on any appreciable scale.

Arakan.—Very little appears to have been done hitherto beyond local attempts to free teak regeneration originating from older plantations.

(v) *Burma and Upper Assam.*

Burma appears to have found that there was more than enough to do in the mixed deciduous forests which contain the valuable teak and useful species such as *pyingado*, and relatively little work of the kind under consideration has been done in the tropical evergreen. In Katha Division (Auktaw, R. F.) some experiments on getting up the abundant *kanyin* (*Dipterocarpus turbinatus*) by manipulation of the canopy and weeding have been tried, and show that development though satisfactory, cannot be expected to be very rapid[21]: this forest is again hardly typical. Some work is also in progress in Petsut R. F., and experimental plots have been laid out.

Upper Assam has hardly touched the problem yet[26], all attempts having been with artificial regeneration—few of them in tropical rain forest, and those mainly on old jhumed areas, or forests more or less altered by heavy working in the past.

(vi) *Andamans.*

The North Andamans was brought under a Working Plan by Todd in 1906, and a revision was made in 1915 for about half the total area. Conditions render the selection system the only possible one, and the clear fellings which have been contemplated are wisely considered dangerous. It is noted in the 1925-26 Annual Report, that no cultural operations are at present practicable; no regeneration operations were undertaken, the fellings being confined to the removal of the mature and overmature stock.

12. Artificial Regeneration.

This subject is also best dealt with by localities, but it may be noted that it is not easy in many cases to make sure from the records that the original forest was of the true tropical evergreen type, and many successfully stocked areas stated to belong here were probably really wet-mixed forest, whilst yet others may have been the real thing originally, but were taken up after ancient jhuming had appreciably altered their character. These remarks must be borne in mind in evaluating the following notes.

(i) *West Coast.*

Bombay.—Judging from the recent Annual Reports, no plantation work has been done in typical rain forest areas.

Coorg.—Although plantations of teak and bamboo have been made at Makut, the sites selected are outside the evergreen area, and the soil is totally unsuitable for teak. The plantations round Mercara are above the limits of altitude under consideration.

Mangalore.—At Jalsur. *Hopea* has been sown (in 1921) in patches spaced 12′ × 12′ under the evergreen forest after light fellings and removal of all the lower canopy up to 25′ high. The plants are only 2′—5′ high, but persist in fair numbers. It is questionable whether results will be obtained in any way comparable to the excellent natural regeneration already referred to.

Chenat Nair.—Experiments were begun in 1921 to devise a practical method of getting up regeneration before the fellings, when it does not already exist on the ground. Sowings and plantings of *Hopea*, *Artocarpus*, *Mangifera* and *Dichopsis* were made in half-acre plots with four variations of canopy manipulation and an untouched control. The best results were obtained when the lower stages were removed, plants surviving in about 25 per cent. of patches and being 1′—3′ high after 3 seasons. Further trials were made in 1924 with sowings of *Mesua* and *Calophyllum*, the former being

a failure and the latter giving 50—60 per cent. survival after 2 years, though the plants were still small and slender; the lowest tree canopy (to 20 ft.) was removed at the beginning of operations.

Tinnevelly.—The cultural operations described above have been liberally supplemented by sowings and plantings costing about Rs. 15 per acre with the usual removal of small trees (all below 2′ girth as a rule). Various species have been used; *Balanocarpus, Gluta, Hardwickia pinnata, Mesua, Pygeum, Vitex, Chickrassia, Acrocarpus,* etc.. though *Hopea* has usually been preferred. In the 1921 area at least, there are a lot of promising plants resulting, but they have yet to be finally freed. It is rather a feature here that the work done has been very scattered, favourable spots likely to give success having advisedly been chosen for such initial experiments. Dealing with an extensive compact coupe would involve further problems not yet tackled.

(ii) *Eastern Himalayas.*

The patches of evergreen forest are commonly included with the wet-mixed and *sal* forests for working purposes in the several Working Plans in force, the idea being to regenerate them by *taungya* methods. There is little doubt but that provided a good burn is obtained and the ground is not too wet, *sal* can be extended beyond its present limits, just as the evergreen types are tending with fire protection to extend over the existing *sal* areas. Some parts, however, probably including much of the type we are interested in, are unsuited to *sal* and different species are being or will be used, the chief being *Lagerstroemia Flos-Reginae,* whilst *Bischofia* is put in the badly drained hollows.

(iii) *Chittagong and Arakan.*

Plantation work has been going on since the seventies along the Chittagong River and some parts at least may well have been originally under evergreen forest, though they had been jhumed before and bamboos had occupied much of the ground, facilitating a clean burn. In the recent *taungyas,* almost all on ground with heavy bamboo growth and therefore *not* primary evergreen, only one year's cultivation is customary, and weedings have to be continued to the 5th year, the weed growth being very heavy. *Bischofia* gives a complete cover 12′ high in three seasons, and *Lagerstroemia Flos-Reginae* has done 45′ high and 4″ diameter in 8 years, whilst of the slower growing species, *Dipterocarpus turbinatus* has reached three feet in two seasons. *Mesua* of 1881 has proved slow, being only 6″ diameter after 45 years, but it is overcrowded; *Swietenia macrophylla* of approximately the same age is 80′ high and up to 18″ diameter. *Taungyas* started in 1923 near Harbang are not too good, but show that the *Dipterocarpus* should offer no special difficulty, (4′—7′/6′ in 4 seasons). No work has been done in virgin forest. Little information appears to have been published on work in Arakan[9], but some degree of success has been obtained with teak *taungya* on evergreen soils.

(iv) *Southern Assam.*

Plantation work has been under trial in Cachar since 1918 when *Mesua* line sowings were made, as well as sowings of *Lophopetalum, Bischofia, Aquilaria,* etc., (the plants are up to 30′ high after 8 years). Clearfelling, burning and broadcasting seed was tried in 1922-23 : the plants are now 10′ high or so, but irregularly distributed and in danger of being smothered. *Gmelina, Cedrela, Artocarpus,* etc., have been sown in patches or transplanted with 6′ × 6′ spacing or along contour lines. Constant weeding has been practised and has resulted in a change to grass which is doubtfully desirable. *Taungyas* since 1922 with teak, at first spaced 30′ × 10′ (now 18′ high), but now down to 30′ × 6′, have been fairly successful, and patch sowings of *Dipterocarpus turbinatus* have done well. In Sylhet, extensive plantations have been made since 1922 on old jhumed areas where the bamboo gives a good burn. Teak and *Gmelina* have been used almost exclusively, and have done well—formerly mixtures of the two species were used, but this is now here as elsewhere abandoned in favour of pure crops of extent varying with the soil.

(v) *Burma.*

As we have seen, *taungya* and plantation work have tended to avoid the real evergreen areas, and the local occurrences in moist hollows, etc., when included have not as a rule been very successful, owing probably to a combination of a less satisfactory burn, less suitable soil conditions for the species sown, and extra heavy weed growth.

In South Tenasserim (Smith[1], *loc. cit.* p. 22). planting operations have been in progress since 1889, more or less continually up to 1923, but only 56 acres are considered worthy to be called plantations. These are all teak, other species having given no results—probably largely owing to bad work. The teak is obviously not at home and *pyingado* not much better. A new start is to be made with *Pterocarpus dalbergioides. Lagerstroemia Flos-Reginae*, and *Lagerstroemia hypoleuca*, while experiments with local species are in progress. The bamboo areas will first be tackled. the sub-evergreen tangle appearing too difficult a problem to be dealt with at present. It is not proposed to do planting work in the 'giant evergreen' forests, in any case.

Upper Assam has done work in Sadiya and Lakhimpur divisions, apart from the plantations in the old jhums at Bogopani. In Jokai, mixed line sowings 33′ apart and 4′ to 12′ wide have been tried using *Morus, Artocarpus, Lagerstroemia Flos-Reginae*, etc., and especially *Terminalia myriocarpa*, this type of work having been started in 1921 by Cooper in Nowgong. It cannot be said that success in Jokai has been definitely obtained; weed-growth is terrific, and if the early promise is to be maintained, the weeding will have to be very carefully watched and will be costly. It will be noted that on account of the *Mesua* regeneration which it is desire to retain, burning is not feasible. A small *taungya* of 1923 planted at 20′ × 4′ with *Cedrela, Morus* and *Terminalia myriocarpa* looks more promising, cattle having helped to keep the weeds in check.

Some interesting work has been in progress since 1923 at Murkong Sillik. After the timber has been logged, 8′ lines are cleared through the debris which is stacked between the lines and burnt as thoroughly as possible. Mixed sowings of *Terminalia myriocarpa, Lagerstroemia Flos-Reginae, Bischofia* and *Cedrela* are made at stakes 10′ apart along the lines. *Morus laevigata* being added later. Costs were Rs. 21 the first year, but have been reduced to Rs. 13 or so since. The 3-year-old plants are up to 15′ high and can hold their own against grass. but the weeds have not been effectively disposed of and climbers threaten to become dangerous. Work in the Sadiya Fuel area is generally similar, but it has cost a great deal. Constant weeding has been done by the Forest Guards, and many of the trees are above the 12′—20′ grass. Quick growing species such as *Duabanga, Kydia* and *Cedrela* have done best. but there is some good *Terminalia myriocarpa*. Here again old jhumed areas with a secondary type of vegetation are in question.

(vi) *Andamans.*[21]

Some teak plantations were made as long ago as 1886-90, and there is a considerable area planted to *padauk*. which is the species chiefly grown. dating back to 1903. Details are not available, but it appears that a good deal of the area may not have been typical tropical evergreen. *Albizzia moluccana* is grown for fuel and shows a phenomenal increment, 6′ trees in 10 years (*loc. cit.* p. 4).

13. Work in other Countries.

A search has been made for literature describing natural or artificial regeneration work in the tropical evergreen forests of other countries, notably the Federated Malay States, the Philippine Islands. Java, West Africa, and Central and Southern America. but virtually nothing has been traced. and it would appear that forestry has advanced no further with them than with us, and for much the same reasons.*

* This remark does not do justice to progress in Malaya, *vide* p. 91, second para.

14. Summary of Present Knowledge.

Owing mainly to the special natural difficulties of the problem, to the greater economic importance of the mixed deciduous forests, and to the outstanding position of teak timber in nearly all the areas concerned, but very little progress has hitherto been made in our knowledge of the regeneration of Indian tropical evergreen forests whether by natural or by artificial means. With the development of markets for the mixed timber from these forests, the question is becoming one of considerable importance, and in view of its unquestioned difficulty, requires to be taken up *before* the forests are submitted to heavy fellings.

It is quite clear that after heavy fellings *not* followed up by cultural operations, regrowth is not satisfactory; at best, the more valuable species on which the fellings are concentrated do not recover their former proportion of the ground, and more usually quick growing inferior and usually deciduous species or bamboo and cane gain the upper hand. Although some indications of a progression back to the original evergreen type can often be discerned, it is unquestionably an extremely slow process, and to rely on it can never be sound forestry. After opening up of the canopy, the equilibrium shews a pronounced tendency to shift more or less toward the next drier type, the moist mixed forest, and it is extremely probable that historically, the tropical evergreen type as a climatic climax has been slowly invasive on territory not originally possessing suitable conditions for it. It should therefore be possible to restock *some* of the ground after clearing or heavy felling with the more valuable species of the moist mixed forest, *i.e.*, teak, *pyinyado* and *padauk*, but these species, particularly the first, will not thrive in typical evergreen areas. A strong burn will favour this retrogression from evergreen as also will repeated jhuming, the common consequence of which is a drying out the soil and development of bamboo growth.

Many evergreen forests contain plenty of small regeneration which if not too suddenly uncovered and if given aid for a few years against competing weeds, is capable of developing into a regrowth better than the original forest. In dealing with extensive areas, however, it will certainly be very irregular, and will fall much short of what is expected of modern forestry operations, and for some forests may fail altogether from want of regeneration at the start or for other reasons.

Attempts at artificial regeneration in this type have met with very partial success, and that mostly in non-typical areas, usually areas which have been jhumed over formerly. The indications are that where conditions are limiting for the evergreen type, standard *taungya* or plantation methods will give satisfactory results, but under typical evergreen conditions, the original species must be used and weedings will be prolonged and costly; weeding can however be done to excess, as an unfavourable mat of grass roots may result, and most evergreen species seem to be helped by some shade at first.

Experiments aiming at the supplementing of natural regeneration by sowings and plantings have not been extensive enough to do more than indicate that there are reasonable prospects of results justifying the expenditure.

15. Proposals for Future Work.

(i) *Fellings.*—In view of our ignorance of the subject and the known marked deterioration of felled-over evergreen forests where regeneration has *not* been obtained, fellings should be held in abeyance as far as possible for a decade, and adequate research undertaken to provide an answer in that time. Where fellings must continue, they should as far as is practicable be of a light selection type breaking the canopy no more than is unavoidable. Where a method of regeneration has been found (as at Makut in Coorg) fellings can continue over such area annually as can be covered by the necessary cultural operations.

(ii) *Research.*—Where the evergreen problem is pressing as in Assam, South Burma and Madras, a special officer should be detailed without delay

for initiating and putting through investigations on an adequate scale: the problem is a difficult one and calls for a man on the spot most of the year, continuously or at frequent intervals. Experiments should be located in as accessible a spot as possible, offering typical conditions as regards type of forest, climate, etc., but otherwise offering the most promising opportunity as regards labour, etc.,—the purely silvicultural problems have to be solved first.

(iii) *Silvicultural System.*—It would seem natural that the true selection system (not the mis-called Indian variety) should be applied to these evergreen forests, but conditions in most of them are such that concentrated extraction is almost a *sine qua non* of the exploitation of the stocks of overmature timber of mixed species which they contain. Even where the so-called selection system is applied and fellings are limited to trees of fairly high diameter, the first cycle usually falls rather drastically on the forest and greatly alters it. Admitting heavy fellings as unavoidable, the alternatives are:—

(*a*) Clearfelling depending on the natural regrowth for regeneration.

(*b*) Clearfelling depending on artificial regeneration with or without field crops.

(*c*) Retention of some sort of shelterwood for a shorter or longer period, with or without seed bearers, to allow of the establishment of a new crop from natural regeneration or artificial regeneration, or both combined.

(*d*) Preliminary operations prior to the commercial fellings, aiming at getting enough regeneration on the ground by natural and artificial means before uncovering.

Which of these alternatives is preferable will depend on local conditions, and on the results of investigations which have for the most part still to be carried out. The lines of such research are considered in the following paras.

(iv) *Natural Regeneration.*—In view of the promising results obtained in Coorg, Tinnevelly, and Cachar, natural regeneration at present offers more hope of success than artificial. Sometimes investigations must begin with getting seedlings on the ground, but more usually the problem is getting up existing seedlings. In the average case, it cannot be expected that natural regeneration will give a full crop consisting mainly of the chosen few more valuable species, and it should generally suffice if operations result in new crop with at least as good a proportion of them. This point requires to be clearly laid down at the start, as if more is demanded, artificial reinforcement will almost certainly be required often under most difficult conditions. Fire cannot be called in as an aid in evergreen forest as it kills most of the species, and so varying manipulation of the several canopy layers is all that can be done, just as was begun in 1921 in Chenat Nair. This work must be tried a few years before the fellings are due. How long it will take and what amount of regeneration is necessary to ensure enough surviving the inevitable felling and extraction damage, also has to be determined. Broad casting or dibbling in seed where seedbearers are absent is only likely to be of use if the conditions under which it can succeed are thoroughly understood first.

(v) *Artificial Regeneration.*—The technique of the chief constituent species, say six of them in the first place, requires thorough study as a first step. This should be done in an experimental garden in the evergreen zone on a moderate scale, and directly the results obtained justify it, tried on an acre under forest conditions both with and without overhead shelter, as is being tried in Chenat Nair in Madras.

Where observation of former clearings or heavy fellings shows that a shift from evergreen condition to wet mixed forest conditions is to be expected, plantations, preferably with *taungya*, of species characteristic of the latter will be at least worth a trial, though it will usually be highly advisable to make trials simultaneously with the species of the evergreen. A strong burn will in all such cases be a first essential to any hope of success.

In view of the inevitable luxuriant weed growth, weedings will be prolonged and costly, and therefore *taungya* is indicated wherever and whenever possible. Where it is not possible on account of lack of labour or steep gradients, plantations will share some of these difficulties, and under present conditions suitably aided natural regeneration offers better prospects.

16. Conclusion.

Fellings of the best trees of the best species without appropriate cultural operations inevitably results in a marked deterioration of all types of mixed forest; in the tropical evergreen this effect is very pronounced, and that the more so, the heavier the fellings.

Natural regeneration is often present in good quantity, and having received suitable help, has in some places been established by the requisite weedings and by avoiding too sudden exposure. Where deficient or small, its quantity can usually be increased by lightening the middle canopy and undergrowth, and to some extent by sowing or planting.

Artificial regeneration offers serious difficulties, particularly in view of the nature of the ground on which much of this forest occurs, and on the need of some shade for the early stages of its chief species—factors rendering *taungya* operations nearly impossible, when in view of the danger from weeds, *taungya* would be doubly valuable. Locally where there is a pronounced dry season and where the evergreen type has probably been invasive in the past, *taungya* and plantations of trees of the moist mixed type should succeed. In the most pronounced forms of evergreen with well distributed and heavy rainfall, *taungya* with technique adapted to the special requirements of the evergreen type species offers most prospect of success where *taungya* is possible, and where it is not, reliance must be placed on natural regeneration obtained, with some artificial help if necessary, prior to any considerable opening up of the canopy.

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PAPER (*ii*)

Contributed by

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The Imperial Silviculturist has been kind enough to send us an advance copy of his note ' for all India ', for criticism and discussion. Mr. Champion has, I think, had access to practically all that has been put on paper in Madras on this subject; and, whilst nothing of any importance can be said in amendment of what he has written, his paper illustrates only how little positive knowledge has been gained in Madras, and that still less has been learnt elsewhere.

In introductory paragraphs, reference is made to the difficulty that at present exists in drawing a line between true " rain forest " and moist mixed forest which contains a high proportion of the species typical of the " rain forest ". Practical difficulty has been experienced lately in this connection in the northern division of South Canara. where the district staff are engaged at the moment in mapping the timber forests, along the Ghat portions, according to types, for purposes of a reconnaissance report. We are having to content ourselves with very rough type definitions : Evergreen, Mixed evergreen and Deciduous, and Deciduous, by which is meant preponderating deciduous, though evergreen species are seldom entirely absent. For the latter two classes it does not seem impossible to devise methods of treatment; and possibly the classification will suffice for more or less pioneer forestry methods. Within the class ' evergreen ' however there are, we have no doubt, much more than one type. A matter for consideration is now to devise a mode of research aiming at identifying evergreen forest *types*. In 1925 to 1926 in a portion of these South Canara timber forests typical of the Ghat and foot-hill localities. a cruising party carried out re-mapping by trailer tape 16″ to the mile scale, and 50 per cent. enumeration over some thousands of acres, it being thought that there were opportunities for a logging project. The results of the cruise are available in the shape of maps that show, by 2 acre rectangles, the volume of the timber-stand. The detail, according to species, is available also in notes. I have meditated embodying the silvicultural data, thus obtained, in fresh maps with corresponding rectangles, coloured, so as to distinguish types of forest. The results of the cruise itself have been to demonstrate the difficulties in formulating any project : so heterogeneous are the crops, both from the " logging project " aspect, and also from the stand-point of the silviculturist. seeking to devise methods for regenerating the areas whose exploitation might be contemplated. I have not in fact proceeded with the ' type ' colouring on the maps for this reason : with our present knowledge. it would be practicable only to adopt arbitrary types based on the relative incidence of evergreen and deciduous ingredients in the stands on individual rectangles : whereas if silvicultural advantage is to be gained, it seems certain that " types " should be based on " tree-associations ", about which I gather none of us as yet know very much. Investigation of the cruise statistics so as to discover " association " is not practicable : timber trees of merchantable quality and size only having been taken into consideration. Moreover, for the most part, this is not a case of virgin forest : the hand of the shifting cultivator having influenced the character of the forest far too much.

Mr. Champion's paper contains such data as he was able to obtain from Madras and Coorg regarding the rate of incidence of evergreen species in certain forests, *vide* his section 4, average figures per 100 acres, in a Coorg forest, trees over $6\frac{3}{4}$ G. B. H. Some new Madras statistics seem likely to be

of interest: a 100 per cent. enumeration of trees, 3′ girth and up, over some 3,000 acres, carried out in the Silent Valley forests of the Palghat Division. This is a Western Ghat forest, practically virgin, (we know that some sleepers of a *Hopea* species, believed to be *H. racophloea*, were stolen from this forest up to about 1911), and a typical "rain forest". Elevation 2,000 to 3,000′. Rainfall unknown; presumably upwards of 100 inches.

The information is as follows:—

Composition of the blocks dealt with:

Timber forest	1,745·3 acres	62·5	per cent.
Reed and scattered timber . . .	554·4 ,,	19·8	
Grass-land and rock	493·3 ,,	17·7	

Total area, 2,793 acres. (This area includes only Blocks I and III out of six Blocks which have been indicated for enumeration. For the compartments that were the enumeration units within the Blocks we have the data separately: as however these compartments themselves were large, their figures if given separately would not be reliable indications in the matter of "associates". The total enumeration figures are given therefore for what they are worth.)

It can be said that these figures are "comparatively reliable". As a matter of fact, few of us have more than a limited capacity for identifying the evergreens.

Serial No.	Species.	Girth.																Buttressed trees, over 8′ girth: girth not specified.	Total.
		3′	4′	5′	6′	7′	8′	9′	10′	11′	12′	13′	14′	15′	16′	17′	18′		
1	*Acrocarpus fraxinifolius*	..	3	10	3	4	6	6	..	2	..	2	1	..	1	..	..	15	53
2	*Adenochlaena indica*	6	23	16	2	..	..	..	..	..	..	..	..	..	..	..	..	..	47
3	*Adina cordifolia*	..	..	..	2	1	1	..	..	..	..	..	..	..	..	..	..	..	4
4	*Alstonia scholaris*	..	1	1	2	..	..	..	1	..	..	..	..	..	..	..	..	..	5
5	*Anogeissus latifolia*	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
6	*Artocarpus integrifolia*	..	36	114	80	34	23	13	1	1	..	..	..	..	..	..	..	2	304
7	*Bischofia javanica*	2	23	26	15	25	21	21	11	5	..	7	1	1	..	..	..	1	158
8	*Calophyllum elatum*	7	263	113	289	226	128	85	54	18	5	19	9	4	6	1	1	..	1,528
9	*Calophyllum Inophyllum*	..	..	1	1	..	1	..	..	..	..	..	..	..	..	..	..	..	3
10	*Calophyllum Wightianum*	..	10	12	7	7	2	..	..	..	..	..	..	..	..	..	..	..	38
11	*Canarium strictum*	1	52	85	37	20	17	9	2	1	..	..	..	..	2	..	..	..	226
12	*Cedrela Toona*	..	..	2	1	1	..	..	..	..	..	..	..	..	..	..	..	..	4
13	*Chickrassia tubularis*	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1
14	*Chrysophyllum Roxburghii*	..	14	38	29	19	14	4	4	..	..	..	..	..	1	..	..	13	136
15	*Cinnamomum zeylanicum*	3	230	222	81	35	23	12	7	5	1	1	..	..	..	..	..	4	624
16	*Colubrina asiatica*	..	2	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	3
17	*Cullenia excelsa*	21	116	139	117	49	53	85	77	1	2	7	1	3	..	..	..	4,588	5,259
18	*Dalbergia latifolia*	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1
19	*Dichopsis elliptica*	121	3,096	1,030	1,821	883	135	177	53	10	2	9	..	2	1	..	..	40	10,680
20	*Dillenia pentagyna*	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1
21	*Diospyros*	..	2	6	2	1	1	..	..	..	..	..	..	..	..	..	..	..	12
22	*Dipterocarpus indicus* (?)	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	2
23	*Dysoxylum malabaricum*	1	37	80	48	27	28	12	4	..	..	2	..	..	..	1	..	23	203
24	*Elaeocarpus serratus*	..	16	46	43	12	11	3	1	..	..	..	..	..	..	..	..	21	153
25	*Elaeocarpus tuberculatus*	3	92	171	165	122	90	56	27	5	1	10	..	1	3	..	..	531	1,273
26	*Elaeodendron glaucum*	..	7	24	24	13	9	10	3	3	..	5	1	..	7	..	2	4	112
27	*Eugenia Gardneri*	4	59	202	138	90	75	40	24	4	1	5	1	1	4	1	..	34	683
28	*Eugenia Jambolana*	..	2	7	9	5	2	..	..	..	..	..	..	..	..	..	..	3	28
29	*Ficus sp.*	..	1	1	4	1	1	..	..	..	1	..	..	..	..	..	..	3	12
30	*Garcinia pictoria*	..	2	5	1	1	..	..	..	..	..	..	..	..	..	..	..	..	9
31	*Garcinia spicata*	1	10	5	1	..	..	..	..	..	..	..	..	..	..	..	..	..	17
32	*Glochidion malabaricum*	..	2	2	1	..	..	..	..	1	..	..	..	..	..	..	..	..	6

Serial No.	Species.	Girth 3′	4′	5′	6′	7′	8′	9′	10	11′	12′	13′	14′	15′	16′	17′	18′	Buttressed trees, over 8′ girth: girth not specified.	Total.
33	*Hemicyclia elata*	34	481	158	129	31	8	2	1	..	1	..	..	..	..	..	..	236	1,384
34	*Heritiera Papilio*	6	151	269	157	86	36	14	3	1	..	..	..	..	1	..	..	71	795
35	*Holigarna Arnottiana*	5	95	134	62	23	4	..	..	..	..	..	..	..	..	..	..	44	367
36	*Hopea racophloca*	3	33	71	33	22	8	13	2	..	..	3	..	..	..	..	..	47	235
37	*Lagerstroemia lanceolata*	..	..	3	5	1	..	..	..	..	..	..	..	..	..	..	..	..	9
38	*Lagerstroemia microcarpa*	..	..	..	3	1	..	..	..	..	..	..	..	..	..	..	..	14	18
39	*Lagerstroemia species*	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
40	*Lansium anamalayanum*	2	40	68	31	12	10	2	2	1	..	..	..	..	..	..	..	1	169
41	*Linociera malabarica*	..	12	1	4	..	1	..	..	..	..	..	..	..	..	..	..	..	18
42	*Litsaea Stocksii*	..	51	72	26	8	7	3	1	..	..	..	..	..	..	..	..	6	174
43	*Litsaea Wightiana*	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	2
44	*Macaranga Roxburghii*	..	2	1	1	2	..	..	..	..	..	..	..	..	..	..	..	1	7
45	*Machilus macrantha*	5	162	325	241	128	80	23	20	2	1	2	..	..	3	1	..	14	1,007
46	*Mangifera indica*	..	7	26	16	13	21	11	4	3	..	3	..	..	2	..	..	3	109
47	*Maslixia arborea*	4	194	379	176	58	20	5	1	..	..	..	..	..	..	..	..	1	838
48	*Melia dubia*	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	2
49	*Melliosma Arniottiana*	..	8	5	5	..	..	..	..	..	..	..	..	..	..	..	..	..	18
50	*Mesua ferrea*	21	896	1,101	1,049	813	624	388	185	61	10	37	11	7	9	1	1	14	5,528
51	*Millingtonia hortensis*	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1
52	*Miscellaneous* (i.e., species not recognised).	3	399	570	232	97	75	45	17	4	..	10	1	..	2	..	..	59	1,514
53	*Myristica attenuata*	..	5	1	..	1	1	..	..	..	..	..	..	..	..	..	..	..	8
54	*Myristica laurifolia*	25	841	809	177	40	10	5	..	..	..	..	..	..	..	..	..	10	1,917
55	*Nephelium Longana*	12	166	242	116	30	15	1	..	1	..	..	..	..	..	..	..	9	592
56	*Polyalthia fragrans*	..	4	7	2	..	1	..	..	..	..	..	..	..	..	..	..	..	14
57	*Sapindus emarginatus*	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1
58	*Schleichera trijuga*	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1
59	*Spondias mangifera*	..	3	6	1	1	..	..	..	..	..	..	..	..	..	..	..	..	11
60	*Stereospermum chelonoides*	..	2	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	4
61	*Terminalia paniculata*	..	..	..	2	..	1	..	..	..	..	..	..	..	..	..	..	..	3
62	*Tetrameles nudiflora*	..	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	3
63	*Tribusa frazinis* (?)	..	..	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	4
64	*Vateria indica*	..	2	1	3	..	..	..	..	..	..	..	..	..	..	..	..	..	6
65	*Vernonia arborea*	..	1	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	4
		290	7,059	10,515	5,394	2,915	1,871	1,046	507	129	25	122	26	19	42	5	4	5,812	36,411

As I have said these figures relate to extensive compartments (enumeration units), and are not of much use for indicating " associations ".

In his conclusion (Sect. 15. p. 107), the *heavy* fellings should be postponed until research in regeneration principles and silviculture generally has made headway, we are, in Madras, in full agreement with Mr. Champion. (We think, in fact, that we are now proceeding on these lines.)

Mr. Champion next discusses systems. It is conceivable that statistics such as I have given above, combined with research into the rate of growth of the principal trees, might enable us to judge whether any form of the " true " selection system would be practicable silviculturally, supposing that it were applicable from the extraction stand-point.

Fellings of what we conclude to be overmature *Mesua*, *Poon*, *Dichopsis* and *Acrocarpus* were commenced in the Silent Valley forest referred to above, in April 1928, and these no doubt are the miscalled " selection fellings " that Mr. Champion has in mind. The process, which is frankly experimental, is being accompanied by attempts at artificial introduction of *Acrocarpus*, and *Artocarpus hirsuta* in the gaps occasioned by fellings. We *may* also try to supplement the natural *Mesua* advance-growth that is present. The fellings are at the rate of about 2 trees per acre, and so far few of the gaps caused are of a size sufficient to occasion misgivings.

It does certainly appear that this first cycle of felling overmature trees must give a far higher yield than can be hoped for from future cycles; and that, were the yield to be less concentrated, there would be little hope of profit. It also seems inconceivable that the true selection system could ever be worked properly with small staff to attend to huge areas, supplied with primitive communications. So it is correct to assume that comparatively heavy fellings will be unavoidable wherever we exploit evergreen forests. Mr. Champion enumerates several forms of treatment. Of these, experience at Chenat Nair forest would lead us unhesitatingly to rule out " Clear-fellings depending on natural regrowth for regeneration ". The second alternative " Clear-felling and artificial regeneration ", would be impracticable in most of our evergreen tracts for lack of labour; but besides this we should consider it a foregone conclusion that the artificial forest would be inferior to the natural crop removed, through deterioration of the locality. So far as Mr. Champion's two remaining alternatives are concerned, the *modus operandi* now under test in the Silent Valley forest may, if we are fortunate, lead to something in the nature of the " group system "; and meanwhile we are in a position to watch in the Coorg forests the development of the crops formed by abrupt removal of all marketable trees, and retention of a shelter-wood consisting of the " unmarketables ". Whilst one could hardly call the Coorg procedure a proved failure yet, the results are extremely uneven: and it is perhaps true to say that tolerable results have been obtained only where *Hopea* happened to be abundant.

In the Coorg experimental areas, the most promising regeneration seen by me was one of Mr. K. Venkatramana Ayyar's plots in which, small advance-growth of especially *Dipterocarpus indicus* being present, middle-storey canopy was removed in 1920. When seen last in 1927, the young stuff was going up, straight and very healthy, and a most satisfactory feature was the absence of climbers.

With regard to preliminary introduction of desirable regeneration, before fellings, or after light fellings, by artificial means, we are finding that tolerable results are obtained by the employment of one, two or three year old transplants, whilst younger transplants, have not given satisfaction.

Subject to the above comments Mr. Champion's proposals regarding the lines on which research should proceed are acceptable. As indicated in earlier paragraphs I feel however that, simultaneous with this research, we should devote attention to definition of types (within the category " rain forest "). It seems more than probable that the presence or absence of particular evergreen ' utility ' trees in different areas is not the result of mere accident. Time and effort may be wasted if, through ignorance of tree-associations, we experiment with silviculture of particular valuable species in

localities where they do not occur naturally. I am not sufficiently expert to say to what extent we shall be helped by learning how Nature groups the evergreens in virgin forest: but at least we should learn in what associations and on what types of locality we may reasonably hope to grow successfully mixed evergreen crops of definite compositions.

I shall attempt to show what little we have learnt about associations. Firstly, in Mr. Champion's Section 5, (p. 95), he mentions *Hopea parviflora*, *Dipterocarpus indicus*, and *Vateria indica* as being "local" in the West Coast tracts: *Hardwickia pinnata*. *Cullenia*, *Balanocarpus*, *Poeciloneuron* and *Gluta* may be added. Of these some grow *gregariously:—Hopea*, *Vateria*, *Poeciloneuron*, and *Balanocarpus*.

From personal knowledge I can only specify a very few "associations": *Hopea* and *Poon*,——examples are to be found in South Canara, (Aletti West, and Sampaji, and Killarmalle Reserves). *Hopea* and *Eugenia Gardneri* (Jalsur Reserve). *Cullenia* and *Dichopsis* (Attapadi Valley, behind Sappal Valley, and I think in Silent Valley also).

Mesua and *Poon* (Neelikal, Silent Valley), I cite with less confidence: they *are* abundant together, but in a mixture with many others.

On the other hand there are others conspicuous for being the reverse of gregarious: *e.g.*, *Acrocarpus* and *Chickrassia tabularis*. (In a note, Mr. Wimbush deprecates for this reason attempts to grow these species as pure crops.)

I doubt if others familiar with our evergreens could add much to the very few observations that I have made regarding associations; for it is a subject that we have not set ourselves to examine. It would be possible to provide some scanty information for Madras as to, "zones"—related to rainfall, elevation, etc.,—in which certain species are confined.

For what it is worth I make the suggestion that graphical representation of the tree-species (I do not know whether it is necessary to include groundflora, but I should think so) on small units of area, might, as was the case with the research in Finland, result in definition of a limited number of distinct types. This graphical work was described to me in Europe by Dr. Heske in 1926: but A. K. Cajander's book, "Theory of forest types", does not give the exact methods employed, and Oxford in 1926 did not seem to have the information either. The task, in the evergreens of Madras, would be arduous for even an expert botanist would find himself hard put to it to recognise many of the species without waiting for them to flower and fruit.

In setting to work to make working schemes or plans for any forest, a first consideration is how to classify the forest according to types. When an evergreen forest is in question, one is faced at the outset by the impossibility, with our present knowledge, of defining types.

PAPER (*iii*)

Contributed by

C. J. ROWBOTHAM, *Silviculturist, Assam.*

(The following paper, Chapter 12 of which has been considerably abridged, conforms with the arrangement of Paper (*i*), q.v., p. 91).

CHAPTER 1.

INTRODUCTORY.

Owing to a number of reasons including lack of communications, limited local demand for timber, want of outside markets, and the extensive areas of the Unclassed State Forests available for exploitation, little attention has been paid until very recent years to regeneration problems in the Reserved evergreen forests of Assam. The ever increasing spread of tea and rice cultivation has now absorbed a great deal of the Unclassed State Forest areas

containing utilisable timber and also considerable sized blocks of Reserved forest under high forest have been disforested for settlement under cultivation. Most of the timber exploited up to date in Assam has been obtained from these two latter mentioned classes of forest. New markets have now come into existence, and the successful results obtained from impregnating a number of semi-softwood species for use as railway sleepers, the local manufacture of three-ply tea boxes on a large scale, and the present demand for timber of a considerable number of hard and soft wood species from Bengal, now constitute a considerable demand on the resources of the existing evergreen Reserved forests, and as artificial plantations can only be done on a limited scale and should only be regarded as a subsidiary source of timber supply, it is necessary to obtain information as to the best method of improving natural regeneration of desirable species in the forest, and to determine to what extent artificial regeneration should be undertaken.

CHAPTER 2.

Synecology.

Taking the two main oecological groups, *i.e.*, (1) climatic or district formations and (2) edaphic or formations depending on soil conditions; the best illustration in Assam of the influence of lesser rainfall in determining the type of existing forest is in the central part of Assam where Lumding on the Assam Bengal Railway, is the centre of a pocket of low rainfall distribution which is sometimes less than 40 inches. Here mixed semi-deciduous and deciduous forest interspersed with savannah forest extends from the Lumding Valley to the lower parts of the Mikir Hills, the North Cachar Hills and the south west plains of Nowgong district. The forests in the Dhansiri valley east of Lumding under similar geological conditions and altitude merge definitely into the evergreen type with 62 inches rainfall.

Incidental factors such as the continual practice of jhuming in the Manipur and Lushai Hills where the rainfall generally varies from about 80 inches to over 100, it would seem, play but an isolated part in preventing the forests from attaining the climax formation, to judge by the persistence of evergreen in steep uncultivable valleys and the obvious tendency of the forests in the neighbouring hills of Cachar to gradually pass from the semi-deciduous type to the evergreen with continual protection from fire.

Edaphic formations are well represented by the replacing of definite evergreen forest by *sal* and mixed deciduous forest in the western portions of Assam without any corresponding reduction of rainfall. Also by the riverain types of forest which persist along both sides of the Brahmaputra river in Sadiya and Lakhimpur. These riverain forests consist of the following types:—

(1) Recent formation of sandy alluvium known locally as "*Chapris*". The characteristic vegetation consists of *Tamarix dioica* with a sprinkling *Bombax malabaricum*, *Phragmites sp.* and at a later stage *Imperata arundinacea*. These tracts are liable to erosion and disappearance.

(2) Alluvial formation which has withstood denudation and erosion. *Tamarix* has disappeared. Growth of more or less mature *Bombax* is often found. The following species are characteristic of the vegetation:—

Albizzia stipulata, *Anthocephalus Cadamba*, *Cordia Myxa*, *Kydia calycina*, *Elaeagnus latifolia*, *Ficus*, *Glochidion sp.* *Olea dioica*, *Alstonia scholaris*, *Erythrina sp.* Occasional *Vatica lancaefolia* and *Bischofia javanica*. *Arundo Donax* occurs in low lying places, and *Anthistiria gigantea* in the more open tracts. Overflooding of these areas is of frequent

occurrence during the rains. Further inland this type merges definitely into the true evergreen type as described below.

(3) Formation of rich alluvium with pockets of clay and swampy holes. Representative species are *Dillenia indica*, *Cryptocarya amygdalina*, *Taraktogenos Kurzii*, *Eugenia sp.*, *Phoebe sp.*, canes often forming into huge brakes, and *Nal.* Ferns of various species frequently occur.

CHAPTER 3.

Distribution and Occurrence.

Areas: Upper Assam 2,286 sqare miles approximately.
Cachar 948 square miles approximately.

The tropical evergreen forests of Assam lie south of the eastern sub-Himalayan tract and are distributed in the Brahmaputra and Surma Valleys and the undermentioned hill ranges.

North of the Brahmaputra this type of forest is present on the lower slopes of the Mishmi, Abor, Daphla and Aka hills and also on the plains below until approaching the banks of the Brahmaputra river and its main tributaries, it is frequently replaced by grass land containing scattered trees of *Bombax malabaricum*. Proceeding further west and south of the Bhutan Hills the forest merges definitely into the mixed semi-deciduous and deciduous type together with extensive stretches of grass land and the *sal* forests of Goalpara.

South of the Brahmaputra it is present on the Naga, Manipur and Lushai Hills on the eastern and south-east frontiers of Assam, though in Manipur and Lushai it is confined to a narrow belt fringing the streams and rivers, the upper slopes and ridges being covered principally with bamboo forest or grass.

The higher slopes of the Mikir Hills in the centre of Upper Assam and the Khasi and Jaintia Hills, where they have not been heavily jhumed contain evergreen forest except on the edge of the western slopes of the Mikir Hills which marks the eastern limit of the natural *sal* zone, and on the northern edge of the Khasi and Jaintia Hills where *sal* is again encountered.

The North Cachar Hills which form a watershed between streams draining into the Brahmaputra and Surma Valleys respectively, contain principally bamboo, grass and deciduous species. The low hills of South Cachar are of the mixed evergreen and semi-deciduous type interpersed with belts of bamboo. Climbers occur far less frequently in these forests than in Upper Assam.

In the plains of Upper Assam there are still some large blocks of evergreen forest in amongst the extensive tea and paddy cultivation.

Generally speaking the evergreen type of forest gradually disappears going from the east side of Assam to the west without any marked falling off in the rainfall, except in the *sal* divisions Kamrup and Nowgong. The normal district averages are as follows:—

	Inches.
Districts North to South on the eastern frontier—	
Sadiya Frontier Tract	143·82
Lakhimpur	113·17
Naga Hills	86·9
Manipur	97·01
Lushai Hills	108·02

	Inches.
Districts North to South in the centre—	
Balipara Frontier Tract	96·54
Darrang	84·38
Nowgong	68·39
Sibsagar	88·19
North Cachar Hills	109·17
Cachar	121·15
Districts North to South in the Western Frontier—	
Kamrup	81·12
Goalpara	109·23
Garo Hills	107·05
Khasi and Jaintia Hills	229·23
Sylhet.	135·45

Attached overleaf is a statement showing the monthly normals of Maximum and Minimum temperatures.

Statement showing the monthly normals of Maximum and minimum temperatures of 9 stations in Assam.

Stations.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
Dibrugarh . . .	71·3	49 9	72·3	54·6	77 8	60·6	79·6	65·4	84·4	70·8	87·0	74·2	86·7	75·4	86·0	75·8	86·5	74·7	84·1	69 8	79·5	60·3	73·4	51·0
Sibsagar	70·0	49·7	72·6	53·3	78·6	59 8	81·2	65·9	85·4	71·5	88·7	76·1	89·2	77·7	88·6	77·6	87·6	76·2	84·1	70 6	77·7	59 6	71·3	50 6
Tezpur	73·6	52·1	76·0	55·7	82·6	61·8	83·4	67·1	86·9	72·3	88·8	76·6	89·2	77·6	89·0	77 7	88 6	76·5	85·8	71·1	80 5	61·1	74·5	53 5
Gauhati . . .	74·6	50·7	77·8	53·0	84·9	59·7	86 0	67·2	88·0	72·3	89·5	76·5	90·2	78·0	90·1	77·8	89·5	76·1	86·9	70·8	81·5	61·0	75·3	52 0
Dhubri	73 8	53 1	77·6	55·9	85·9	62·9	87·5	69 8	86·3	73·1	85 9	76 2	85·9	78·2	86·1	78 5	85·5	77·2	84·5	72·7	79·8	63·7	74 3	55 1
Shillong	60·6	39·2	62·5	42·2	70 0	50·8	73 3	56 3	74·0	59 8	74·4	63 0	75·3	64·3	74·9	63·7	74·1	61·7	71·4	54 8	66 6	46·5	61·6	39·7
Cherra-Punjee . .	60·3	45·9	63 0	47·7	67 8	53 9	70 2	57 6	72·3	60·4	73·1	64·0	72 2	65·0	72 2	65 0	73·4	64 3	71 9	60·3	67·9	54·0	64·9	47·4
Silchar	77 9	52·5	80·5	55·7	85 9	64·1	87·7	68·8	88·7	72·6	89·3	76 1	90·0	77·2	89 6	76·8	89·8	76·2	88 6	72·3	85 0	63·5	79·6	54·7
Srimangal . . .	80 6	47·8	83·2	51·7	89·1	60·9	90·7	68·5	91·2	72·0	90·2	75·3	90·3	76 2	90·3	76·0	90·8	75 0	89·6	70·1	86 6	59·4	80·9	49·7

The soils* are for the most part of recent alluvial formation and are composed of a mixture of sand and clay in varying proportions. Overlying strata are for the most part in the east of Assam, sandstone of Nummulitic age or shales. Alternate layers of clay and sand belonging to the Upper Tippam Series are a typical formation in the hills of Jaipur and Upper Dehing (southern portion) Reserves. Limestone occurs frequently in the central hills of Assam. Volcanic outcrops do not seem to occur anywhere. The basis of the Assam Range of hills is a gneissic rock and outliers of this are common between Goalpara and Gauhati, and are found as far east as Tezpur.

The Surma Valley is an alluvial tract, in which the process of deltain formation has not proceeded so rapidly as in the rest of the Gangetic plain. Low ranges of hills consisting chiefly of Upper Tertiary sandstones project into the valley from the south and its surface is dotted with isolated hills called tilas, composed of layers of sand, clay, and gravel often highly indurated with ferruginous cement.

CHAPTER 4.

Composition.

The prevailing feature of the forests of Assam in general is the considerable mixture of species and the representation of the more valuable ones as scattered single trees and occasionally in small clumps. Among the more characteristic species of the lower hills and valleys of Upper Assam are *Mesua ferrea, Artocarpus Chaplasha, A. integrifolia, Dipterocarpus pilosus, Amoora Wallichii, Vatica lanceaefolia, Terminalia myriocarpa, Shorea assamica, Cinnamomum cecidodaphne, Dysoxylum binectariferum, Altingia excelsa, Garcinia spp., Eugenia spp., Carallia lucida, Aquilaria Agallocha, Morus laevigata; Sterculia alata, Cedrela Toona, C. myriocarpa, Gmelina arborea, Stereospermum chelonoides, Tetrameles nudiflora, Duabanga sonneratioides, Ficus spp., Magnolia spp.* (including *Michelia Champaca, Manglietia insignis, Talauma phellocarpa*), *Anthocephalus Cadamba, Kayea assamica, Sapium baccatum, Gynocardia odorata.* Amongst bamboos, *Dendrocalamus Hamiltonii, Teinostachyum Dullooa, Bambusa pallida* are commonly represented.

The following species are typical of the forests in the plains of Upper Assam and alongside river banks:—*Lagerstroemia Flos-Reginae, L. parviflora, Bischofia javanica, Phoebe Hainesiana* (found frequently also in valleys of hill areas) *Terminalia myriocarpa, T. Chebula, Dillenia indica, Macaranga spp., Bombax malabaricum, Albizzia procera, A. lucida, Duabanga sonneratioides, Elaecarpus assamica, Cedrela Toona. Bambusa Tulda, Bambusa Balcooa, Arundinaria spinosa.*

Amongst the above mentioned species *Dipterocarpus pilosus* is practically confined to the hills and plains adjacent to the Naga Hills region, *Shorea assamica* is found in the same locality and also in the hills of the Sadiya Frontier Tract wherever the overlying strata consists of alluvial gravel and clay, and *Kayea assamica* is seldom found outside North Lakhimpur. The best quality of forest as regards stocking undoubtedly occurs in the hilly portions, or on well drained slopes where greater height growth is also attained and climbers are not so prevalent as in the low lying portions, *Mesua ferrea* is ubiquitous on the heavier soils and the same may be said of *Artocarpus Chaplasha.*

CHAPTER 5.

Local forms.

Distinct local forms of evergreen forest are to be observed in certain localities, as regards the predominance of certain species. In the Sadiya

* Reference Imperial Gazetteer of India.

Frontier Tract on leaving the riverain tracts of grass and *Bombax malabaricum*, *Terminalia myriocarpa* becomes the commonest species and approaching the hills it is frequently found growing as pure forest, trees 100 to 120 feet in height and over 20 feet in girth being not uncommon.

In the outlying portions of the Naga Hills in the Lakhimpur District the best quality forests have been classified as follows :—

(1) High evergreen forest consisting chiefly of *Shorea assamica* and *Mesua ferrea*.

(2) High evergreen forest containing chiefly *Dipterocarpus pilosus* and *Mesua ferrea*, but without *Shorea assamica*.

In (1) and (2) the species mentioned attain a semi-gregarious character and the prevailing species in the underwood is *Vatica lanceaefolia*. *Livistona Jenkinsiana* is conspicuous in the undergrowth of these forests.

Both *Dipterocarpus pilosus* and *Shorea assamica* can attain girths up to 20 feet and clear boles of over 100 feet.

Mesua ferrea does not commonly exceed 7'-6" in girth, though trees of 12' and over have been measured. These are generally found to be unsound.

Low level forests are seldom of any great value except as a source of supply of cane, except in the central plains forests of Sibsagar where *Lagerstroemia Flos-Reginae* constitutes a fair percentage of the stocking. Different forms of forest where fast growing deciduous species are more numerous than the evergreen have come into existence in other hilly portions of Assam through the agency of jhuming in the past.

The North Cachar Hills and Khasi and Jaintia Hills which constitute the watershed between the Brahmaputra and Surma Valleys are also the dividing line between certain varieties of forest growth found in Cachar forests as distinct from those of Upper Assam. While both valleys possess a large number of species in common, in Cachar are found the following :—

Dipterocarpus turbinatus, *Alseodaphne Owdenii*, *Machilus villosa*, *Michelia montana*, *Cinnamomum oblongifolia*, *Isonandra polyantha*, *Cynometra polyandra*, *Lophopetalum Wightianum*.

The following species of bamboo occur in Cachar forests for the most part in extensive pure groups :—

Melocanna bambusoides (the commonest and not found in Upper Assam) also *Bambusa Balcooa*, *Teinostachyum Dullooa*, *Melocanna humilis*, *Pseudostachyum polymorphum*, *Bambusa pallida*, *Dendrocalamus Hamiltonii*, *Dinochloa M'Clellandii*.

Generally speaking the hill forests of Cachar can be divided into three types :—

(1) A mixed largely evergreen type confined generally to northern and eastern aspects, steep uncultivable slopes and rocky and shady narrow banks of small streams.

(2) A mixed semi-deciduous type with some evergreen species which occupies the greater part of the rest of the area.

(3) The grass areas which are generally confined to the banks of the main rivers and the broader estuaries of the side streams.

The first two types merge into each other a great deal. The origin of the second type is probably due to the practice of jhuming, which was prevalent in these forests before reservation. The process can still be seen in the Lushai Hills and in Khas land of Cachar wherever jhuming is permitted. Further the semi-deciduous forests of Cachar show a decided tendency to pass more and more into the evergreen type than do those of the Lushai area where jhuming is still permitted.

Better protection from fire has there resulted in the formation of more definitely marked and compact evergreen forest in Cachar than in the Lushai Hills.

CHAPTER 6.

Destructive agencies, past and present.

As indicated in the earlier Chapters the necessity for providing sufficient areas to accommodate the jhuming tribes has been and is still the cause of depleting the greater portion of the hill areas of utilisable forest. No check on this depletion is known except perhaps the introduction of terraced cultivation in parts of the Naga Hills where the angle of the slopes permit this. Attempts have also been made to induce the Nagas to sow broadcast seeds of local fast growing inferior species on their abandoned jhums. If this was put into general practice it would permit of shorter jhuming rotations over more compact areas.

Lopping of trees over small areas of several bighas each is done sporadically by hill tribes to enable them to cultivate the pan vine. The areas so treated seem insignificant, but the selective requirements of the cultivators in choosing favourable areas for growing pan lead to accessible valuable forests on the banks of streams being honeycombed with ruined patches of forest and to friction between timber traders and cultivators in political areas on account of the damage done by the traders dragging elephants.

Professional buffalo graziers are for the most accommodated in the existing grass areas in the plains, but it has been found necessary to restrict their numbers in the hills, as after their arrival little is left surviving except short stunted grass The spread of tea and rice cultivation has undoubtedly been permitted without due regard being paid to the necessity for leaving sufficient sources of timber and fuel supply for local requirements in certain districts of the province so much so that in spite of selected areas being now demarcated as village forests, there are many extensive tracts of cultivation left without a stick of fuel.

The effects of natural pests ranging from grazing animals down to defoliators, shoot borers and fungi on artificial plantations require no discussion here, and very little is known as to the extent of their influence in natural evergreen forest.

CHAPTER 7.

Residual area.

The approximate areas or portions of Reserved forests in Assam which consist of evergreen forest are given below division by division after exclusion of areas coming definitely under deciduous and grass types.

	Square miles.
Upper Assam—	
Sadiya Division	341
Lakhimpur Division	374
Sibsagar Division	929
Nowgong Division	356
Darrang Division	221
Khasi and Jaintia Hills Division	65
Total	2,286
Cachar	948

It is impossible to form any estimate of areas of Unclassed State Forests still under primary tropical evergreen forest in the hills in the Sadiya Frontier Tract, the Naga Hills, Mikir Hills, Khasi and Jaintia Hills, Lushai Hills and Garo Hills, owing to most of them having come under short interval jhuming, and to the original evergreen forest being now confined for the most part to rocky valleys and portions of slopes not suitable for cultivation. Surviving Unclassed State Forests in the plains may be ruled out of consideration as they are ear marked for settlement under permanent cultivation.

Private forests of the evergreen type are confined practically to the Manipur State. Here again owing to short interval jhuming they consist chiefly of a narrow belt fringing the rivers which drain into the Surma Valley, and it is difficult to make a guess at the area. The supply of timber from them, on the royalty of which the Government of Assam receives a ¼th share, is not inconsiderable, but they have been heavily tapped for many years of trees 6′ in girth and over and the Manipur State is only interested in them from a revenue point of view and beyond spending a little money on blasting boulders which block up waterways, expend nothing on their improvement or maintenance.

CHAPTER 8.

Natural Regeneration (Spontaneous).

From the observations recorded by officers in the different evergreen forest Divisions of Assam during the last ten years, it is apparent that the extent of natural regeneration that occurs at the present day in these forests varies considerably for the different species, and again individual species have been found to regenerate themselves much better in some localities than others, owing to certain peculiarities in the soil or absence of undergrowth having favoured them.

Terminalia myriocarpa, the principle species of the plains of the Sadiya Frontier Tract, apparently requires a good soil free from organic matter and plenty of light. It dislikes direct overhead shade and decaying vegetable matter in the soil. Advance regeneration even in blanks in existing stands of overmature *Terminalia* is said not to be found except on areas of freshly deposited silt, which has killed off existing undergrowth or on jhumed areas exposed to the sun and burnt over, and under these conditions it is found to be profuse. Clear felling of undergrowth is therefore indicated when attempting to induce natural regeneration, and the latter must be protected by weeding operations if it is not to disappear in two or three years' time. The natural regeneration of *Bombax malabaricum* and *Duabanga sonneratioides* and *Morus laevigata* in Sadiya is also dependent on the action of rivers in depositing silt, but such regeneration is, however, liable to be washed away in its turn or killed by more deposits of silt.

In the sub-montane reserved forests of North Lakhimpur, *Kayea assamica*, which occurs rarely anywhere else, here grows gregariously on gravelly loam, and numerous seedlings are found round the mother trees, this kind of soil not being favourable to luxuriant weed growth or climbers.

In the hilly portions of the Upper Dehing and Jaipur Reserves, adjacent to the Naga Hills, *Dipterocarpus pilosus*, *Shorea assamica*, *Mesua ferrea* and *Vatica lanceaefolia* undoubtedly reproduce themselves very well according as they find favourable conditions of soil, and in well stocked forests containing all girth classes of these species, numerous seedlings are found on the ground also. The extent to which overhead tree cover may be diminished to establish the seedlings and prevent suppression by incoming weeds requires careful study. Other species which reproduce themselves well in these moist forests, through in no way gregariously, are *Artocarpus Chaplasha*, *Terminalia myriocarpa*, *Cedrela Toona*, *Lagerstroemia Flos-Reginae*. *Morus laevigata* and *Altingia excelsa*. Natural regeneration of *Amoora Wallichii*, species of *Magnoliacae*, *Cinnamomum cecidodaphne*, *Stereospermum chelonoides* and *Schima Wallichii* is rather scarce. In the case of some of the latter mentioned species, the production of a considerable proportion of sterile seed may be the cause of poor reproduction.

In the plains evergreen forests of Lakhimpur, where the soil is enriched by erosion from lower hills, as distinct from the riverain tracts where mixed semi-deciduous species prevail, most of the species belonging to the Lakhimpur hills forests are represented, though rather more sporadically except in the case of *Mesua ferrea*, *Altingia excelsa* and *Lagerstroemia Flos-Reginae*,

which three often occur in small groups. A denser type of undergrowth is encountered here which impedes spontaneous natural regeneration.

In the extensive plains forests of Sibsagar Division where the principal important species are *Lagerstroemia Flos-Reginae, Terminalia myriocarpa* and *Phoebe Hainesiana*, the stocking is generally bad. No doubt owing to incomplete overhead canopies, natural regeneration of these species though it occurs is almost invariably choked by weeds. On the slightly higher parts of these plains, groups of *Mesua ferrea* occur, for the most part mixed with other species. Underneath the shade of the latter, sapling and pole growth of *Mesua ferrea* is frequently found to persist. The species *Amoora Wallichii* and *Cedrela Toona*, although they produce plenty of fertile seed, are very sporadic in these forests.

In the forests of Cachar, it is admitted by officers familiar with them, there is certainly much more natural regeneration than in the evergreen forests of the Assam Valley. In the Working Plan report for this Division it is stated that on the whole the distribution of age classes for most timber species is fair. In the semi-deciduous type of forest which is showing a tendency to pass into the evergreen type the conditions at present appear to be favourable for the natural regeneration and subsequent upward growth of certain shade bearing and shade demanding species, including *Dipterocarpus turbinatus, Artocarpus Chaplasha, Podocarpus neriifolia, Alseodaphne Owdenii* and other species of the *Lauraceae, Amoora spp., Michelia montana* and *Aquilaria Agallocha*. The distribution of some of these species in stretches of bamboo forest, through the agency of birds, frequently occurs.

Isonandra polyantha, a species at present not much in demand, regenerates itself more profusely than any of the other species and forms almost pure woods in the lower hills.

Specimen trees of 26 species have been selected and kept under observation for a time in Cachar after freeing them of creepers and other tree species where they were suppressed, and clearing of undergrowth beneath the trees. Amongst the information elicited from these observations by Mr. Owden, it was seen that after freeing trees as above described it took some three years for them to pick up in the matter of seed bearing and then they bore profusely. Good flowering years by no means necessarily meant good seed years and *vice versâ*. A good deal depended on the climate at the time during the year and individual trees displayed eccentricites, *e.g.*, of two *Alseodaphne Owdenii* trees comparatively close together and apparently of the same age, one flowered profusely and fruited well and the other did not even flower. Many trees though fruiting profusely seldom have any regeneration of their own species beneath them, but in some way supply really good regeneration within a radius of 50′ to 100′ of the tree. Amongst these latter are quoted *Podocarpus neriifolia, Amoora spp.* and *Alseodaphne Owdenii* and other species of the Lauraceae, though these generally have a much wider distribution.

Other species observed to have given good natural regeneration were *Artocarpus Chaplasha* (especially between 5′ and 6′ girth). *Isonandra polyantha, Calophyllum polyanthum, Dipterocarpus turbinatus, Aquilaria Agallocha, Eugenia cymosa* and *Eugenia praecox*.

Generally speaking regeneration of a species under mother trees of that species was observed to be best in respect of those which have a heavy seed not devoured by birds or animals.

CHAPTER 9

Changes on clearing or heavy felling.

As in the case of spontaneous natural regeneration, very varying results have been recorded in different localities following exploitation of mature and over-mature trees. In Sadiya where plenty of clearance is made in felling all mature *Terminalia myriocarpa* stems in the better class forests

and the soil is wounded and exposed by felling and dragging operations natural regeneration of *Terminalia* and *Morus laevigata* comes up freely in dense patches, but unless freed from weeds and climbers for about the first three years would inevitably be choked and killed out.

In the Lakhimpur Division this subject requires further practical observation and experiments. The earliest experiment traceable was made in the Upper Dehing Reserve, West Block, where following on exploitation of 184 mature trees over a demarcated area of 100 acres in March 1921 two sample areas were selected and each was divided into three blocks (each 25′ × 25′) and treated as follows:—

Block (1) Undergrowth was cut with the intention of burning, but burning failed entirely owing to rain.

Block (2) Undergrowth was cut.

Block (3) This was left untreated.

The results of enumeration of natural regeneration in the two sample areas are summarised below:—

Block No.	Species.	No. of seedlings found on 27th May 1921.	No. of seedlings found on 10th May 1922.
	Sample Area I.		
1	*Mesua ferrea*	5	1
	Dipterocarpus pilosus	1	1
	Albizzia lucida	12	2
2	*Mesua ferrea*	8	3
	Dipterocarpus pilosus	13	6
	Albizzia lucida	21	9
	Eugenia praecox	3	1
3	*Mesua ferrea*	12	8
	Dipterocarpus pilosus	18	3
	Albizzia lucida	7	1
	Eugenia praecox	1	1
	Dysoxylum Hamiltonii	—	1
	Albizzia procera	—	1
	Sample Area II.		
1	*Mesua ferrea*	2	1
	Dipterocarpus pilosus	2	5
2	*Mesua ferrea*	1	2
	Dipterocarpus pilosus	10	6
	Stereospermum chelonoides	1	—
3	*Mesua ferrea*	1	1
	Dipterocarpus pilosus	16	—
	Albizzia lucida	1	1
	Albizzia procera	—	2
	Magnolia sp.	—	1

The canopy in Sample Area II was very much more open than in No. I.

To form a comparison, a counting of seedlings in virgin forest of similar type in the year 1921 gave the following figures per acre:—

Mesua ferrea	548 or 8	on area 25′ × 25′.
Dipterocarpus pilosus	720 or 10	,, ,, ,,
Artocarpus Chaplasha	648 or 9	,, ,, ,,
Total	1,916 or 27	,, ,, ,,

In this area climber cutting was done and undergrowth removed from part.

No further records of this particular experiment were apparently kept.

Present day observations show that the fellings done for exploitation of *Mesua ferrea* sleepers in the Upper Dehing Reserve, West Block about the year 1912 have in some instances induced natural regeneration of *Terminalia myriocarpa, Dipterocarpus pilosus* and *Mesua ferrea.*

In the year 1919-1920 experimental regeneration fellings were carried out in small plots varying in size from 1 to 10 acres in the Nambor, Diphu Reserves (Sibsagar) and Dhansiri Reserve (Nowgong) in evergreen forests of three types, *viz.* :—

Type I.—Containing a sufficient number of mother trees of the more valuable species.

Type II.—Containing an insufficient number of such trees.

Type III.—Where there are no such trees. This type occurs over very large portions of the Diphu, Nambor and Rengma Reserves and are for the most part " ponzo " (signifying dense advance growth of soft wood species usually found on sites of deserted jhums).

A summary of the results of these experiments is as follows :—

Type I.—Very fair natural regeneration was obtained by merely removing everything except the mother trees and by cutting and burning the undergrowth. Principal species regenerated were *Duabanga sonneratioides, Terminalia myriocarpa, Phoebe Hainesiana, Artocarpus Chaplasha, Bischofia javanica, Cinnamomum cecidodaphne, Gmelina arborea, Tetrameles nudiflora.* Enumeration in 1921 showed about 100 seedlings per acre. Weeding and partial removal of overhead cover was continued up to the year 1926-27. Total cost per acre from commencement averaged about Rs. 28. Present day results show fair regeneration of the species mentioned and good growth, but the stocking is nothing like full and cannot be so without artificial aid.

Type II.—This type of forest is found in the Dhansiri Reserve (Nowgong) and experimental plots were made where *Phoebe Hainesiana* was the principal important species. The removal of over-mature trees in 1919-20 and intensive climber cutting opened up the forest to a certain extent and enabled desirable species to develop their crowns and produce more seed. The operation so far as the natural regeneration of *Phoebe Hainesiana* was concerned was satisfactory and resulted in the appearance of a very large number of seedlings. Burning was not found necessary in the Dhansiri Reserve to regenerate this species naturally, but the reverse was the case in the Diphu and Nambor Reserves. Such regeneration as abovementioned seems to have been regarded as merely local and insufficient for restocking areas on a large scale as further experiments were carried out to assist induced natural regeneration with artificial sowing of *Phoebe* and other local species. Good germination was reported to have occurred. A later report in 1926 on these experimental areas states that some of the plants survived and the rest were all swamped by *Eupatorium*, and that some of the plants had grown as high as 38′, but were not worth taking into consideration from a plantation point of view.

The Divisional Forest Officer of Nowgong states that at the present day the reproduction of *Phoebe* in areas of the Dhansiri Reserve after exploitation by purchase con-

tractors is conspicuous by its absence. Apparently this species germinates but requires further assistance to establish itself.

Type III.—In this type of forest it was realised that little reliance could be placed on the few existing mother trees of valuable species for regenerating selected areas and so in the experimental plots, artificial sowing of local species including *Amoora Wallichii*, *Phoebe Hainesiana*, *Bischofia javanica*, *Lagerstroemia Flos-Reginae* and *L. parviflora* was done at stake subsquent to the cutting of numerous climbers, and with the idea of gradually removing the overhead cover of soft wooded species as the seedlings grew into saplings.

Successful germination seems to have been obtained wherever cutting and burning of undergrowth was done in these plots, but the difficulty lay in avoiding the enormous mass of weeds, chiefly *Eupatorium*, which came in once overhead cover was reduced. These plots were abandoned about six years after commencement and the results obtained do not appear to be commensurate with the expenditure (between Rs. 20 and Rs. 30 per acre) incurred.

The Divisional Forest Officer who was in charge of them advocated regular taungya plantations as the only really satisfactory method of restocking these areas.

In the more poorly stocked forests enumeration surveys have indicated that not more than 25 per cent. of the area contained forest of any value and that over the remaining 75 per cent. the forest is so poor that it will be impossible to restock an exploited area except by planting.

Comments have been made in the previous Chapter as to the changes following felling or cleaning in the Cachar forests. These have been far more heavily exploited than those of Assam and the opinion of the officer who prepared the Cachar Working Plan appears to be that the younger girth classes of useful species are fairly well represented and that he is by no means pessimistic about the restocking of periodically exploited areas by nature.

CHAPTER 10.

Selection Fellings.

It is remarked by Mr. Champion in his paper " that selection felling concentrated on a few species, if no special measures are taken, must result in a steady if slow reduction in the proportionate representation of these species ". This may be the case with certain species as regards some of the plains evergreen forests in Assam, south of the Brahmaputra where the more valuable species, with the exception perhaps of *Mesua ferrea*, *Lagerstroemia Flos-Reginae*, *Phoebe Hainesiana* and *Altingia excelsa* do not display gregarious tendencies. *Artocarpus Chaplasha* however is one of the trees most heavily exploited in Assam and in spite of this its natural regeneration is very general throughout the forests in all stages of growth.

The most striking illustration is afforded by those tracts of plains evergreen forest traversed by the Assam Bengal Railway, where along a narrow belt on either side of the railway line the forests, after being cleaned of mature trees of *Phoebe*, *Amoora*, *Morus laevigata*, *Cinnamomum cecidodaphne* and *Cedrela Toona* are now stocked for the most part with only inferior species. The present poor stocking of the majority of those parts of the plains forests accessible by road and river may also be partly attributed to this selective system of felling a few species only, added to the fact that the younger girth classes of the latter are seldom well represented. Even granted that felling and conversion into planks and beams of a few

valuable species has only been done in these plains forests on a very limited scale in earlier years, the choosing of species for constructing dugouts by local villagers has, in the absence of any restrictions, led to some of them being heavily exploited, the more favourite species for boat making being *Artocarpus Chaplasha*, *Cinnamomum cecidodaphne*, *Cedrela Toona*, *Lagerstroemia Flos-Reginae* and *Terminalia myriocarpa*.

In the Sadiya Frontier Tract *Cinnamomum cecidodaphne* is, it is reported, now getting rare owing to its being cut very extensively for dugouts. *Morus laevigata* has also been all along utilised in preference to any other species in Sadiya for making paddles for boats.

The forests of Cachar have not suffered so heavily in this respect perhaps because of the far larger number of timber species including soft woods, which in nearly all cases are extracted by river and are looked upon as utilisable in Sylhet and Bengal.

CHAPTER 11.

Improvement works attempted with natural regeneration.

Reference has already been made in Chapter 9 of this paper to the nature and scope of the experiments which have been made over small plots in connection with this work Provision has been made for it on some scale in the Cachar Working Plan, and will be made for it in future Working Plans for the Upper Brahmaputra forests wherever there is likelihood of obtaining successful natural regeneration.

One of the most promising localities, as far as is known at present, is in the better quality forests in Sadiya.

The Sadiya enumeration survey made in 1919-1920 by Mr. H. L. Cooper gives the percentages of the different classes of forest as follows:—

1st class 1·74 containing 7 stems and over of 6′ girth per acre.

2nd class 4·41 containing 5 to 7 stems and over of 6′ girth per acre.

3rd class 18·19 containing 3 to 5 stems and over of 6′ girth per acre.

4th and 5th class 75·66 containing less than any of the above.

In 200 acres of 1st class forest in Sadiya exploited last year for *Terminalia myriocarpa* by the Assam Saw Mills Company there are reported to be heavy crops of *Terminalia* seedlings now about 3 feet high along the dragging paths and round stumps of felled trees.

The weeding of this area will be undertaken in the current year and the cost for the first year's weeding is estimated at Rs. 4 per acre.

The present programme of artificial regeneration by broadcast sowing in belts should however remain in force for the 3rd, 4th and 5th class forests in Sadiya.

CHAPTER 12. [Abridged:]

Artificial regeneration.

(a) *Existing species* versus teak, etc.

The earliest known teak plantations, at Kulsi in Kamrup Division, cover 140 acres, and were made between 1872 and 1882. The best girth is 10′-2″ and height somewhat exceeds 100′. The adjoining natural forest is good quality *Shorea robusta*, so that the area was probably not typical tropical evergreen. From 1921-1925, silvicultural policy particularly in Cachar and Sylhet, was directed to creating large pure teak taungya plantations on ground carrying bamboos (*Melocanna bambusoides* and *Teinostachyum Dullooa*) and mixed evergreen of little value Interplanting was done with a variety of species. The teak reached a height of 12′-30′ in the second

year. It has been found since that the teak has stagnated after the first year or two in grassy areas and on laterite, whereas the other species are healthy, especially *Gmelina arborea* which has outgrown the teak. On better soils, the teak is still doing well, particularly where bamboo or *Mallotus* and *Macaranga* have come up with it.

(b) *Taungya work.*

Taungya operations are mainly confined to the Surma Valley where alone labour is procurable. Teak and *Gmelina* are the species most used. Spacing in the first year is 30′ × 8′ or 18′ × 9′ (usually teak). two or one intermediate lines being planted the next year (usually *Gmelina* stumps). Taungya in Upper Assam with other local species, especially *Terminalia myriocarpa* and *Lagerstromia Flos-Reginae*, have done reasonably well. Broadcast sowing in strips 6′ wide have been most successful with sugar-cane between.

(c) *Plantations.*

1. Results with individual species may be summarised as follows:—

1. *Amoora Wallichii.* 6′ strips broadcast have given fair results, whereas a 3 acre pure plantation is not promising. Average height in 6 years is 16′ (maximum 28′).
2. *Artocarpus Chaplasha.* Difficult to transplant but germinates well. Dislikes direct exposure and does well under high overhead tree cover. It has been known to reach 38′ height in 5 years. It is much used for filling gaps in plantations of other species.
3. *Cedrela Toona.* Easy to introduce, but much browsed and insect attacked. Rate of height growth is about 5′ a year in the early stages.
4. *Dipterocarpus pilosus.* In strip sowings has done reasonably well.
5. *Dipterocarpus turbinatus.* A small area planted 12′ × 6′ under bamboo is developing slowly, and the 6′ × 12′ 7 years old plants seem likely to push through in time.
6. *Gmelina arborea.* Grows very rapidly, 30′ to 40′ in 4 seasons, but is badly browsed in some areas.
7. *Lagerstroemia Flos-Reginae.* Grown pure on heavier soils on low but not frequently flooded land. Overhead shade is not tolerated. Very close spacing, 4′ × 4′ is found advisable to give straight stems.
8. *Morus laevigata.* Extremely rapid growing, up to 20′ in the first year, but gets browsed badly where deer are abundant.
9. *Terminalia myriocarpa.* This is the most used species in Upper Assam. Direct sowings on 6′ cleared lines, 20′ centre to centre, have developed well being weeded for 2 years, and beginning to close up and kill out the grass after the 3rd year when they will be 20′ height.

2. *Spacing in plantations.*—6′ × 6′ for stake planting is recommended as the maximum spacing. For belt sowings, 6′ should be the minimum width and 14′ for the intervening strips.

3. *Fencing.*—Conditions vary and must be judged in each case. The belt sowings do not appear to be much damaged by game.

4. *Area of plantations created.*—Up to the end of the year 1926-27, the total area of plantations not under Working Plans (as distinct from taungyas) created in Assam evergreen forest is shown as about 4,770 acres. This figure includes about 3,200 acres of *Bombax malabaricum* plantation in mixed forest in Sadiya. At least two or three hundred acres of the plantation areas might be written off as failed experiments. *Note*: Plantations and taungyas created in Upper Assam have been in the plains forests, and in the Surma Valley on undulating land and low hills.

5. *Labour supply.*—Only in the Surma Valley are we able to obtain sufficient forest villagers to undertake a regular planting programme. In Upper Assam there is so much land available for settlement outside Reserve Forests that the Department has to rely on such casual labour as is obtainable in heavy competition with local tea gardens and prices of wages are continually rising. Such few forest villagers as there are, are unwilling to give their ten days paid labour per man in the year, even though they are only charged one anna six pies land revenue per bigha instead of from one to two rupees per bigha.

The only solution appears to be to import labour from outside and instal it in forest villages on reasonable terms, having regard both to the villagers' interests and the labour demands of the Forest Department.

(d) *Costs.*

Very variable according to whether fuel is extracted or not, mode of stocking and so on. Rs. 20 to Rs. 50 per acre covers most of the work done, 2-3 years weeding being usual, and costing more than the initial work.

CHAPTER 13.

Work in other countries.

No remarks are required here.

CHAPTER 14.

Summary of present knowledge.

As the extent of natural regeneration both spontaneous and following heavy felling differs somewhat amongst the different local forms of evergreen forest in Assam, some variety of method must accordingly be applied in attempting to regenerate them. In forests where spontaneous natural regeneration is good, *e.g.*, Jaipur and parts of Upper Dehing Reserve there seems to be no reason why restricted fellings of mature trees under the Selection system should destroy the present formation of the forest much more than occasional gaps do that are caused by death from old age and windfall. Where natural regeneration of desirable species is conspicuous by its absence, as appears to be often the case in some of the Assam Forests, a regular programme of taungya or departmental plantations should follow heavy exploitation. Further observations must still be made as to the amount of natural regeneration that does occur. The few small isolated experiments that have been made to supplement natural regeneration by sowing in poor quality forests containing few valuable stems afford no idea of the probable cost of doing it over large areas, and the task of protecting scattered patches of successful germination against weeds (*e.g.*, Eupatorium) which come in with the removal of overhead tree cover, is not likely to prove successful over extensive areas, to judge by the results obtained in the small experimental plots.

In creating regular departmental plantations it has been observed that the lack of or the partial success obtained by any departure from orthodox close spacing, *e.g.*, 6′ × 6′, does not seem to be accompanied by or compensated for by any very marked economy in expenditure. To judge from the results of wide spacing and the analysis of costs given in Chapter 12, it does not cost much more to establish a canopy closed up after about three or four years than to raise an incomplete stocking of scattered saplings out of reach of weeds and inferior species.

Timely sowing has been proved to be one of the principal factors of success, and the best time for sowing seeds of any species as determined by actual experiment should be adhered to, and if sowing direct in plantations:

in due season is to be done punctually, previous exploitation of the area for timber is best done a year beforehand, and final clear felling must be taken in hand early in the cold weather to ensure obtaining a good burning of the debris.

Whether sowing direct or transplanting is to be done depends largely on the percentage of germination ordinarily obtained and on the supply of seed obtainable. Broadcast sowing in belts has generally given the most luxuriant and vigorous growth in the earliest stages.

In the selection of species for planting or sowing it is considered safer to choose local existing ones, and suitable mixtures have yet to be studied properly.

For species possessing marked shade bearing qualities, an overhead crop of *Tephrosia candida* or *Macaranga* is recommended. This also helps to reduce the costs of weeding.

CHAPTER 15.

Proposals for future work.

(i) *Fellings and Silvicultural System.*

Except perhaps in the Surma Valley the number of species selected for removal by purchasers under the Indian variety of the selection system has hitherto been limited to a few or sometimes only one in the various localities, which in the case of forests not containing useful species of a semi-gregarious character has resulted in favouring the less valuable ones. In addition to those species which have been found suitable for use as sleepers after antiseptic treatment, more information is now required as to possible use of others, whether as ply-wood or for other purposes. The obtaining of this information might pave the way to starting local factories and enable a more regular system of felling to be introduced.

The prescriptions of the Working Plan under preparation for the hill forests of Lakhimpur and Sibsagar where largely semi-gregarious species will be exploited, should in addition to felling of mature and overmature trees, aim at group natural regeneration assisted by artificial sowing of *Dipterocarpus pilosus, Shorea assamica, Mesua ferrea, Altingia excelsa* and *Artocarpus Chaplasha.* Weeding and climber cutting would be required in accordance with the intensity of the felling and also improvement felling to prevent undesirable species from suppressing the others. These suggestions apply to the better class areas which comprise first and second and third quality forests as determined by enumeration survey. In lesser quality forests containing valuable species of good stem growth but poorly stocked with them, artificial regeneration under the *taungya* method or by regular plantations should be resorted to.

A Working Plan is also required for the Sadiya Reserves, where the present programme of artificial regeneration on clear felled areas only covers a portion of the areas exploited for mature *Terminalia myriocarpa.* This species germinates sufficiently well in Sadiya to make it worth while attempting to assist natural regeneration by weeding and improvement felling in exploited first and second quality forest.

In the Working Plan for Cachar forests provision has been made—

(*a*) Natural Regeneration Felling Series in which the regeneration of shade bearing species in groups under shelter woods will be attempted.

(*b*) Artificial regeneration Blocks, each of which will be treated independently.

In these certain light demanders, the natural regeneration of which is not good and which require the open conditions of the jhum to go ahead at first will be raised under the taungya method or departmental plantations. Areas prescribed for treatment under (*a*) comprise 2,919 acres and under, (*b*) 3,066 acres.

(ii) *Research.*

In addition to research experiments being carried out by special officers, Divisional Officers and their Range Officers might be called upon to make and record observations of growth occurring subsequent to exploitation of coupes marked for felling, so far as their other duties left them time to visit them.

(iii) *Artificial Regeneration.*

The taungya method is preferable to regular departmental planting in so far as it enables us to undertake larger areas and as regards cost. In taungya operations the chief danger to avoid is over exposure of the soil after cultivation of crops is finished. Within the belts staked out for sowing or planting of selected species, a closed up canopy is essential, and in the interspaces between belts the crops should be succeeded by broadcast sown *Macaranga* in order to avoid the following possibilities, *e.g.*, the establishment of a dense matting of short grass, *Eupatorium* or fast growing inferior species which unlike *Macaranga* tend rather to suppress than to nurse the plants, or elephant grass. Anything like heavy grazing by cattle has proved disastrous and left only a matting of grass on the soil between the belts.

CHAPTER 16.

Conclusions.

Conclusions have been already dealt with by Mr. Champion in his Paper. In respect of Upper Assam it might be added that there is no prospect of carrying out an increased programme of plantations without a regular system of forest villages recruited by imported labour.

CHAPTER 17.

Additional Bibliography.

1. Report on the Forest Resources of the Abor Country . . A. J. W. Milroy.
2. Preliminary Working Plan Report for the Upper Dehing Reserve, West Block and the Jaipur Reserve . . F. H. Cavendish.
3. Working Plan of the Cachar Forests. (Not yet published) . J. S. Owden.

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Report of Debate.

Chairman: Mr. Minchin will kindly open the debate on item No. 9.

Mr. Minchin. At the outset Mr. Champion sent the Madras Silviculturist, and presumably some of the other provincial silviculturists, a paper intended to cover the subject for all India. To me. it gave the impression that a vision had appeared to Mr. Champion, and it was said to him. "Write up an account of the regeneration of evergreen forest." He replied. "But I don't know anything about it", but received the response: "Nor does anyone else know much about it. Collect what information you can. and set the matter going". The paper I referred to is the outcome, and it was suggested that we should take it as a basis, and criticise and amend.

Mr. Champion's note ends with definite proposals regarding future policy and research.

Madras and Assam contributed rather lengthy notes; but neither found anything of importance to quarrel with in Mr. Champion's proposals, nor much that was vital to add to them.

Since then brief remarks have come from Coorg, accepting Mr. Champion's proposals, and commenting.

For Bombay, the Chief Conservator of Forests wrote to the effect that fellings in their evergreens would not be profitable, unless on a scale that would make their results dangerous climatically.

Mr. Blanford sent a note on evergreen forests in the Malay. It is not a commentary on the Conference papers on the subject, though it adds much force to part of Mr. Champion's suggestions. It is encouraging to learn that *someone* is really succeeding with exploitation *and* regeneration in tropical evergreen.

Other Provinces have not commented.

The issue in fact narrows down to consideration of Mr. Champion's proposals: with only about one another proposal to add.

All that we can attempt at this meeting is generalisation on questions of *principle*.

These are some points in Mr. Champion's paper:—

Firstly, what type of evergreen forest are we considering? Only the real *tropical* evergreen or rainforest. Exact definition is not easy but Mr. Champion makes it clear what he means by this.

He deals with distribution, composition, etc., etc., and ultimately gets on to actual experience of exploitation. (The *financial* success of exploitation is outside the terms of reference). Attempts at exploitation have ranged from selection to absolute clearfelling. The degree of success achieved in *regenerating* is described. Examples of artificial regeneration work, and of measures for the benefit of existing natural regeneration, are discussed.

We ought to be clear as to what is to be meant by *success* in regenerating the rain forest. Take an extreme case:—Suppose we cut down a block of *rainforest* and replant it with a good deciduous crop: would that exemplify precisely "regeneration of the evergreen"?

Can we assume as the ideal, that the forest treated is not to change appreciably from the rain forest type to a drier type? If so, we can draw this conclusion from the exploitation that has been done; success with regeneration has been relatively most satisfactory where fellings have been the lightest. Directly heavy fellings are undertaken, important factors are disturbed; just the very factors that cause a forest *to be* true rainforest.

Apart from degree of humidity in soil and atmosphere, and light intensity, Mr. Champion quotes a sentence about rainforest *soil*, written by an authority: It seems to me to get to the root of the matter:—"It appears that the rainforest is very little dependent on the soil, which may be shallow even to an extreme, and when exposed to light and air what we should call a *very poor one*. The forest has apparently evolved a system of living largely on the products of its own decay". Mr. Champion adds:—"Though the soil underlying many of our rainforests is undoubtedly good, it may be remarked in most, how the trees spread over the rocky outcrops which get re-exposed very rapidly on destruction of the continuity of the canopy".

The note makes an attempt to cover briefly most recorded instances in which Forest people in India have tried to exercise their skill upon evergreens. Near the close he takes stock of what has been learnt:—

Firstly, owing to the difficulties of the problem, and claims of adjacent deciduous forests, (particularly teak forests), *little progress* has been made in study of *Indian* evergreen regeneration natural or artificial.

Secondly, recent circumstances have begun to develop *markets* for evergreen woods. The need for studying evergreen regeneration principles has become pressing in certain provinces. The regeneration problem should be taken up *before* we subject our forests to heavy fellings.

(In parenthesis, Madras took a plunge in exploitation before learning on an adequate experimental scale what could be done in the way of regeneration. Now the difficulties in regeneration have become apparent, and we should almost like to cry a halt. But circumstances press us to go on with what we have begun.)

Thirdly, comes a generalisation that after heavy fellings *not* followed up by cultural operations, regrowth is *not* satisfactory.

Fourthly, when rainforest is opened up the type tends to shift towards the next drier type namely " moist mixed forest ". Recovery in the opposite direction is known to occur, but it is too slow a process for reliance to be placed on it in forestry.

Fifthly, having perpetrated fellings that depreciate a rainforest to moist mixed type, it *is* possible artificially to re-stock at all events some part of the ground affected with useful species characteristic of the moist mixed type, teak, *pyingado*, or padauk.

Sixthly, many rainforests have plenty of small regeneration, and if this is uncovered with due restraint *and* if assisted in the struggle with weeds and inferior species, one can expect to bring in forest superior to the virgin forest in the more favourable places.. But it is emphasised that *consistent* results cannot be expected over *extensive* areas: and that in some forests there will be an absolute failure,—for lack of regeneration. or for some other reason, such as latent *Strobilanthes* vegetation which becomes overwhelming when light is admitted.

Finally, experiment in *supplementing* natural regeneration, by sowing or planting, has not yet gone far enough to do more than encourage us: but there are prospects that results will justify the expenditure.

Mr. Champion concludes by making proposals consistent with his stock-taking:—

(i) *Fellings.*—In view of our ignorance of the subject and the known marked deterioration of felled-over evergreen forests where regeneration has *not* been obtained. fellings should be held in abeyance as far as possible *for a decade*, and adequate research undertaken to provide an answer in that time. Where fellings must continue, they should, as far as is practicable, be of a light selection type breaking the canopy no more than is unavoidable. Where a method of regeneration has been found (as at Makut in Coorg) fellings can continue over such area annually as can be covered by the necessary cultural operations.

Comment from Coorg is thus:—

Mr. Robinson would prefer to stop fellings, if and when finance permit, as he has grave doubts of the current methods.

(ii) *Research.*—Where the evergreen problem is pressing as in Assam, South Burma and Madras, a special officer should be detailed, without delay, for initiating and putting through investigations, on an adequate scale: the problem is a difficult one and calls for a man on the spot most of the year, continuously or at frequent intervals. Experiments should be located in as accessible a spot as possible. offering typical conditions as regards type of forest, climate, etc., but otherwise offering the most promising opportunity as regards labour, etc.—the purely silvicultural problems have to be solved first.

Coorg remarks that it should share in the investigation with Madras. Also that there is an additional problem, how to exterminate rubbish such as *Ochlandra* reed that overwhelms regeneration when fellings are done.

(iii) *Silvicultural system.*—It would seem natural that the true selection system (not the mis-called Indian variety) should be applied to these evergreen forests, but conditions in most of them are such that concentrated extraction is almost a *sine qua non* of the exploitation of the stocks of over-mature timber of mixed species which they contain. Even where the " so-called selection system " *is* applied and fellings are limited to trees of fairly high diameter the *first* cycle usually falls rather drastically on the forest and greatly alters it.,

Admitting *heavy* fellings as unavoidable, the alternatives (to the selection method) are:—

(*a*) Clearfelling depending on the natural regrowth for regeneration.

(*b*) Clearfelling depending on artificial regeneration with or without field crops.

(*c*) Retention of some sort of shelterwood for a shorter or longer period, with or without seedbearers, to allow of the establishment of a new crop from natural regeneration or artificial regeneration, or both combined.

(*d*) Preliminary operations prior to the commercial fellings, aiming at getting enough regeneration on the ground (by natural and artificial means) *before* uncovering.

Which of these alternatives is preferable will depend on local conditions and on the results of investigations which have (for the most part) still to be carried out.

Mr. Blanford shows that Malay Foresters have done much work, successfully, somewhat on the line of (*d*).

The Malay species are quite distinct from ours, but now we have read Mr. Blanford's note, I think Madras men are sure to go to Malay forests for inspiration.

The remaining two of Mr. Champion's proposal paragraphs are complementary to those I read out. The lines on which research is to be pursued are suggested. I will not delay you by reading them out. The proposals include the case of fellings that are expected to lead to degradation from rain type to a drier type.

One additional theme has been attempted in the Madras Note, namely that it is desirable that we should learn to define local forest sub-types, within the category " rainforest ".

A second stage would be to try to determine what sub-types had corresponding features, though differing in point of species.

What we are getting at is this:—At the present stage, speaking broadly, in our various writings we discuss the success of various attempts at regeneration research in what we call merely " rainforest " or " evergreen ". Well, the term is far too broad and unwieldy. We know that the composition of rainforest differs from place to place and from province to province.

The associations of species in a virgin crop are surely the expression of the factors of that restricted locality.

If that is so, then any research results should have reference, not broadly to rainforest, of character unspecified, but to definable sub-types of rainforest.

Until research results are so to speak " *tied* " to a particular sub-type, it is almost dangerous to publish them. I have been avoiding reference to particular instances, cited at some length in the Conference papers for that reason. In fact, I have set out to keep to the ' general ' and avoided the ' particular '.

Some sub-types are recognised in Assam. From Mr. Blanford's note on Malay work, it appears that foresters there have certain sub-types that they recognise. But it is not clear that these sub-types are definable according to any system at present. In Madras, we can indicate a few sub-types:—Crops of the few species that occurs almost pure: *Hopea parviflora*, *Vateria*, etc. Secondly, (in a very restricted way) a few sub-types of greatly mixed species, in which particular important trees are associated noticeably: for example " *Hopea* and *Poon* " and another " *Cullenia* and *Dichopsis* ".

I do not presume to suggest how the study and classification of sub-types is to be pursued: that is where the specialist should come in: but I think the problem should be tackled, side by side, with the work indicated by Mr. Champion.

There is another point that seems worth mentioning:—

As a help towards framing a research programme, a declaration from a Local Government as to its policy regarding rainforest would be desirable.

For example, the scope for research is narrowed down very much if a Government has a rooted objection to an exploited forest degrading to a drier type.

When the Conference has considered matters, the resolution I should suggest is :—

(1) This Conference regards as reliable the summary of knowledge hitherto gained, as set forth in Section 14 of the Central Silviculturist's note on regeneration of the evergreens: and recommends to provinces concerned with the problem of evergreen regeneration, adoption of the policy and proposals embodied in Section 15 of the same note.

(2) The Conference, recognising that results of evergreen regeneration research work cannot adequately be expressed without reference to the forest sub-type within which the research has been conducted, desires a commencement to be made in classifying rainforest according to sub-types.

Chairman : Will Mr. Rowbotham tell us his opinions on this subject?

Mr. Rowbotham : I would make the following comments on Mr. Champion's proposals for future work :—

(*a*) " Clear felling depending on the natural regrowth for regeneration ". Clear felling alone is out of the question and would only lead to a mass of inferior species springing up over the areas.

(*b*) " Clear felling depending on artificial regeneration with or without field crops "

The species artificially produced would have to be fast growing and probably not the same species as were originally on the ground.

(*c*) " Retention of some sort of shelterwood for a shorter or longer period with or without seed bearers, etc.".

The true Selection System seems to be the most suitable, but while natural regeneration of evergreen *Dipterocarpus* and *Mesua* is frequently to be found on the ground prior to doing any fellings, I personally have not noticed any fresh natural regeneration of these species occurring subsequent to fellings.

(*d*) " Preliminary operations prior to the commercial fellings, etc." The most urgent operation required is climber cutting, which should be done throughout the area. In my own province, it is considered that a climber cutting should be done 5 years before the felling, and a second cutting done a year before the felling. The killing off of climbers in the upper storey will have the effect of slight reducing the overhead canopy, and perhaps of bringing the trees into a better condition for production of seed.

Any further remarks I might make about natural regeneration I am reserving for the next Item, Number 10.

[*Mr. Blanford* then drew attention to the necessity for classifying the main sub-types of evergreen before research into the problems of regeneration could be tackled He criticised the local classification of evergreen forest in Mr. Champion's note and pointed out that Lower Burma evergreen was quite distinct from Upper Burma evergreen, a brief description of the method of regeneration in evergreen forests in Malaya was given.]

Mr. Shebbeare : Nobody knows what 'Evergreen' means. 'Rainforest' is a preferable term.

The incidence of *Dipterocarpus* might be a basis for sub-type classification.

Taungya is a possible regeneration method: but would change the type. *Acrocarpus* is an illustration of a species that can be raised by taungya on felled-over rainforest soil. Unregulated fellings in evergreen are very dangerous.

Mr. Champion : My paper is headed " *Tropical* " Evergreen, an expression which in the general literature on the subject is treated as synonymous with " Rainforest "; the first word is essential in any case. Personally, I incline to Mr. Smith's term " Giant Evergreen " in the present connection.

Mr. Robinson : I am in entire agreement with Mr. Champion's proposal that fellings should as far as possible be held in abeyance until we know more about regeneration.

In Coorg, big scale exploitation was started some few years back, before much was known about regeneration. The result turned out very fairly satisfactory. This exploitation on a big scale came to an end, and before we begin again the problem of regeneration should be gone into very carefully.

The regeneration we get in Coorg is all advance growth. Mr. Rowbotham spoke of the difficulties experienced in Assam in introducing natural regeneration in such forest after felling and I believe the same difficulties would be met with in Coorg, and therefore, where exploitation is likely to be on such a large scale as 1 square mile per annum, as in Coorg, it is essential that we should either be sure that we have sufficient advance growth already existing, or should know exactly how to establish such regeneration in the blanks sufficiently well ahead of the felling.

The difference between sub-types is a most important one, and results obtained in one may well not be obtainable in another. For this reason it is even dangerous to publish results. In Coorg, we had a certain measure of success, and I believe this was responsible for starting large scale work in Madras in the expectation of getting the same results. For this reason I have tried to keep what information I have from becoming general.

[*Mr. Barrington* referred to the transition in Burma from *Indaing* on soils with usually 75 per cent. coarse sand, though *Semi-Indaing* with *Pentacme* and *Shorea obtusa*, to evergreen.]

[*Messrs. Davis* (Bombay), *Garland* (Bombay) and *Littlewood* (Madras) were invited to speak, but had nothing to add.]

Mr. Champion : As my paper has been used as a basis for discussion, I would like to touch on one or two points.

Mr. Minchin's diagnosis of the causes leading up to the writing of the paper was extraordinarily near the truth.

The question of the classification of types of evergreen has been mentioned more than once, and actually I think the remarks made by previous speakers have already brought out the fact that it is an extremely difficult problem. I have seen very few serious attempts to deal with it. One of the best is that by Major Chipp in some of the West African forests. He is an expert botanist. Something is certainly extremely necessary. We shall have to be careful in choice of terms. Reference to the percentage of Dipterocarpus will not, I think, work in practice, but I think it might be investigated. Almost my only source of information for South Burma was H. Smith's excellent working plan, to supplement which I could only find Dudley Stamp's " Vegetation of Burma " in which the " Evergreen Dipterocarp forest " of South Burma is distinguished from the " Wet evergreen " type. When I was collecting the information available, I found that no one seemed to deal with the border line between the two types. Now the region of heavy rainfall as seen on the rainfall maps runs right up the east side along the Salween to Upper Burma and Assam, and it is for that reason that I thought it better to keep those types together. I hope Mr. Blanford will give me a little more information on that point.

My conclusions do not appear to have been altered by this debate. The main point is that the Conference should pass a resolution recommending the provinces which are concerned, to go slow in making heavy fellings in evergreen forests; and the second is that we should, while we have the opportunity, do research work *before* the demand for information arises instead of letting it overtake us first, as has actually been the case in Madras from what Mr. Minchin has said.

Chairman : I think we have had a most interesting debate, and we are certainly all agreed that investigation of tropical evergreen is a matter not only of very great scientific interest, but of forest importance. Although tropical evergreen forests at present may not do very much for the forest revenues of India, it will be a very good thing to investigate this matter before these forests come under exploitation. We have already had experience in Madras, where exploitation operations were on a very large scale carried out before anything was known on the subject, and I think that we are all agreed that this matter should now be investigated.

ITEM 10.

ARTIFICIAL REGENERATION WITH SELECTION SYSTEM IN MIXED FORESTS.

Two papers were contributed, by Messrs. Rowbotham (Assam, *vide infra*) and Laurie (Madras, *vide* page 140).

Notes were received from Messrs. Newman (Bombay) and Garland (*cf.* page 143), giving further opinions and details of the type of work described by Mr. Laurie.

The debate (*cf.* page 144) was opened by Mr. Rowbotham, who read a summary from the papers and added a few remarks. Messrs. Blanford (Burma) and Shebbeare (Bengal) referred to the considerable amount of labour and expenditure incurred on this type of work in their provinces with a minimum of results. Messrs. Glover (Punjab) and Sher Singh (Kashmir) told the Conference of their experience in mixed deodar and fir forests, reporting some measure of success. The Chairman summarised the debate, and a resolution, proposed by Mr. Rowbotham (Assam) and seconded by Mr. Chaturvedi (United Provinces), was passed.

Resolution 10.

Resolved *that this Conference considers that artificial regeneration of light demanding species in gaps caused by fellings made under the true Selection System is not likely to be successful, and that, although artificial regeneration of shade bearing species under similar conditions seems more promising, the experiments already begun should be continued further before conclusions can safely be drawn, owing to the slow growth of these species.*

A further report should be submitted to the next Silvicultural Conference.

Paper (*i*)

Contributed by

C. J. Rowbotham, *Silviculturist, Assam.*

A certain amount of regular exploitation has been done under the Selection System in the following Reserves in Assam :—

(1) Upper Dehing Reserve, West Block. In 1913-14 Selection felling combined with improvement felling was carried out over an area of about two square miles of the hills portion of the Reserve to supply timber for the Naharkatiya Sawmills. Mature and overmature trees and also a certain number of smaller badly shaped stems of all valuable species were felled. No weeding or improvement felling amongst the inferior species or artificial sowing was done in this area. In spite of this there are reported to be at the present day quite good clumps of natural regeneration of *Terminalia myriocarpa*, *Dipterocarpus pilosus* and *Mesua ferrea* coming up in the gaps created by felling.

(2) In the Upper Dehing Reserve, West Block, Upper Dehing Reserve, East Block and the Jaipur Reserve, 320 acres, 240 acres and 220 acres respectively, were exploited in the year 1926-27. All mature trees of valuable species were felled. No reports have been sent in as yet concerning the appearance of natural regeneration of *Dipterocarpus* spp., *Mesua*, *Shorea assamica*, etc., but an examination of these areas will be made in the current year.

From the promising results in area (1) above mentioned, it seems that artificial sowing combined with Selection felling *cum* Improvement felling

should do much towards enlarging the existing groups of the semi-gregarious species above mentioned. The Improvement fellings in future should include the partial removal of overhead cover of inferior species, but in the opinion of the writer this should be very carefully regulated to prevent heavy growth of weeds, and notably of *Eupatorium* which has spread all over Assam and Cachar forests wherever clearings have been made. Following the exploitation of coupes under the Selection *cum* Improvement felling system, weeding for two to three years would be required wherever regeneration was obtained, followed very likely by another Improvement felling to remove more inferior tree species wherever they stood over established regeneration of the valuable species. The number of coupes to be treated as suggested above would depend largely on the amount of forest staff and money available.

The above suggestions apply more to shade bearings species. As regards the regeneration of light demanders in mixed forest, it is impossible to say without experience, whether artificial regeneration combined with Selection felling would prove a satisfactory method. Mr. Owden in his Cachar Working Plan Report gives the opinion that certain light demanders require the open condition of the jhum to go ahead at first, and from his remarks it appears also that the natural regeneration of the light demanders is not so good as in the case of the shade bearers.

PAPER (*ii*)

Contributed by

M. V. LAURIE, *Working Plans Officer, Mt. Stuart, Madras.*

Note on Experiments in Artificial Regeneration in "Funnels" in mixed Deciduous Forest at Mount Stuart.

The purpose of these experiments was to try to find out some means of artificial regeneration suitable to the simple selection system of working, as generally carried out in mixed deciduous forests in India. By the selection system in this case, I mean the method of exploitation by felling all saleable trees over a given girth limit. Forests worked by this method inevitably tend to degenerate, because many of the best seed bearers of the valuable species are removed at each felling, while the useless species are left to regenerate themselves in the gaps left by felling the good species. These experiments in regeneration by "funnels" devised in order to try and find out a practical, and not too expensive method of counteracting this degeneration, and improving the forest.

2. A "funnel" is merely a gap in the canopy left where a tree has been felled, which admits direct light at a certain angle to the ground beneath it. It is found in practice that the gaps left are usually very small, and that the chief gap in the canopy is not where the tree originally stood, but where the crown has fallen. In bamboo forest especially, the gaps are very small, and often insignificant, even where quite a large tree has stood. It is probable that in actual practice, when regenerating a selection-felled coupe by this method, it will be necessary to enlarge the gaps already existing, or even to make new funnels by felling, or girdling inferior species. Such measures would however tend to increase the cost considerably.

3. Some similar experiments were carried out many years ago in Begur Range, of the Wynaad Division, but all records of the experiments have been lost. Here and there. these patches of teak regeneration are found throughout the forest, and the results seem to be reasonably encouraging. The method of artificial regeneration in "Rab" patches, as done in Bombay, is somewhat similar, but in these, the "Rabs" are very much larger than "funnels", and other conditions are different. The "funnel" experiments may be regarded in part as an attempt to apply the method of patch regeneration in gaps used in Corsica, to Indian conditions. (A short description of the Corsican method is given in "Practical Forest Managament", by Trevor and Smythies, pages 80-82.)

4. The experiments at Mount Stuart were carried out as follows. Some 30 " funnels " were choosen in the current year's selection-felled coupe during the month of December. The largest available gaps in the canopy were selected, but it was difficult to find enough gaps of sufficient size. No artificial enlarging of the gaps was done, and the average solid angle of light at the centre of each funnel varied from about 30° to 90°. In selecting the funnels, places were chosen where a sufficient quantity of branchwood from a felled tree was easily accessible.

5. During January and February the branch-wood was billeted, and stacked in the middle of the " funnel ". The piles were usually about 5 feet high, and 12 to 20 feet in diameter. There was never any difficulty in obtaining sufficient material for a really hot burn. The ground was scraped clean all round each pile, to prevent fire escaping into the surrounding forest, and the stacks were burnt about the middle of March. The heat given out by the burning of stacks was terrific, and the soil was often burnt to a red clinker under the stacks. In spite of all precautions, fire escaped from one funnel and burnt about 100 acres of forest, including about a dozen other funnels. Scarcely any damage was done by the fire, and several natural funnels, where fallen trees had been burnt, were sown up with good results. I do not think that it will be possible in actual practice to prevent fires from escaping from funnels unless great expenditure is incurred. A funnel cannot be considered " safe ", until about 24 hours after the burn, since a very light wind will blow small pieces of glowing charcoal off the patch into the dry leaves on the ground round about, and so start a fire.

6. The funnels were sown up at the end of March by dibbling seed in loosened patches. The patches were about 3'-4' apart—sometimes closer—and about half a dozen seeds were sown in each patch. The funnels were treated in different ways, but in all cases teak was sown in the patches within the area of the actual burn. In some funnels, teak was sown right out to the edge of the funnel, and in others, *Terminalia tomentosa*, and *Pterocarpus Marsupium* were sown round the periphery of the funnels. Later on just before the rains, *Dalbergia latifolia* and *Lagerstroemia lanceolata* were also introduced.

7. One weeding was carried out in late July and early August, round the periphery of each funnel, where the weed growth was very dense. The burnt patches were almost completely free from weeds, though it is difficult to say whether this would be the case in a normal season. The South-West Monsoon was very poor this year, and the rainfall was less than one-third of the average. Probably in a normal year one weeding might be necessary in the actual burnt patches.

8. The teak germinated well in most of the funnels, but in one or two, where the burn had been too hot, and the soil had been burnt to a red colour, it failed to germinate.

9. A certain amount of natural regeneration has also come into the funnels. The chief species to appear are *Stephegyne parvifolia*, *Adina cordifolia* and *Bridelia retusa*. The first mentioned has come in very abundantly in the burnt portions in some funnels, but it is too soon to say whether it will interfere with the teak. It was interesting to notice that where the original tree which had been felled was a teak tree, dormant seed from the previous year germinated freely in the periphery of several funnels. It never appeared in the burnt patches.

10. It is too soon to say as yet, whether the method is likely to be a success. At the end of August, however, there was a good stock of small seedlings of all the species sown, and they were looking fairly healthy. The growth was, if anything, a little better than in the plantations made in clear-felled areas at the same date, and there certainly was less trouble from weeds. The third weeding was in progress in the plantations at the same time as the first weeding was being carried out in the funnels. The effects of drip were apparent in several cases, but it did not seem adversely to affect the seedlings.

11. The following points appear from the experiment, to be advisable:—

(1) The area of the burn should be as large as possible.

(2) The burn should not be too hot. The best result was obtained in a funnel where a large flat pile was made, about 4′ high and 20′ in diameter, composed of small twigs and branches up to about 3″ diameter only. Large logs give too hot a burn, and they are also more costly to cut up and stack.

(3) When doing a number of funnels in an area, it would be cheaper to fire-protect the whole area by a fire-line round it, and not to attempt to protect each funnel individually.

(4) Before sowing it is better to spread the ashes over the whole area to be sown.

(5) The first weeding in the periphery of the funnel should be carried out early in July in a normal year. Another weeding may be necessary at the beginning of October.

12. Regarding expenditure, it is very difficult to form an estimate of the cost of the method when done on a large scale. The following, however, gives a rough idea of the cost of each operation. If coolies at 8 annas are used, the respective costs will be Rs. 2-5-4 maximum, and Re. 1-2 minimum respectively.

Description of work.	Number of coolies employed and the amount of work turned out.	Coolies at 12 annas Cost per patch	
		From	To
		Rs. A. P.	Rs. A. P.
Billeting and piling	6 coolies could do from 3 to 7 patches per day.	1 8 0	0 10 0
Burning	2 coolies can clear round and burn 3 to 6 patches per day.	0 8 0	0 4 0
Spreading ash and dibbling, etc.	The expenditure depends upon many factors, *e.g.*, size of funnel, number of patches—whether staked, etc.	0 6 0	0 4 0
Cost of seed	1 bag at Rs. 1-8 of all species is sufficient for about 50 funnels.	0 0 6	0 0 6
Extras	Purchase of tools, etc.	0 1 0	*Nil*
1st Weeding	3 female coolies did 9 patches per day thoroughly.	0 8 0	0 4 0
2nd Weeding	(*If necessary*)	*0 8 0*	*0 4 0*
	Total expenditure in 1st year	3 7 6	1 10 6
	or	3 8 0	1 11 0

13. The costs are based on figures for a few funnels, scattered over a large area. The work was done in many cases with an unnecessary amount of care,—each funnel was individually fire-protected and watched until nightfall after the burn; fairly large logs were billeted and stacked in most of the funnels, some funnels were stacked before sowing and so forth, so that it is very difficult to get even an approximate idea of the cost. I feel confident that if the method were carried out on a large scale, costs could be reduced so as to approximate to Re. 1 per funnel for the first reason.

14. The method on a large scale would probably be carried out as follows. The selection of the funnels would be done by the District Forest Officer or the Ranger, and, where necessary funnels would have to be made artificially by felling or girdling useless species. The work would be entrusted to a special duty guard, who would be given the necessary coolies for billeting and stacking the material for the burn, and for fire-protecting the

whole area. The funnels in the area would all be burnt at the same time, and the fire allowed to escape from the funnels. After the burn, the guard would be made responsible for raising so many seedlings in so many patches, and after instructing him in the best method of doing so, he would sow the patches and tend them as was found necessary. He would be paid the wages of one, or if necessary two coolies a day to help him, according to the number of funnels he had to look after, and he would have to produce so many well stocked funnels at the end of the first year. He would probably employ his family for the work.

15. It will be necessary to do further experiments on a large scale more or less according to the method outlined above before it will be possible to say how it will work in actual practice.

16. The ultimate result in a coupe that has been regenerated by funnels will be an increase in the stocking of valuable species by a process similar to Nature's own method, but speeded up, and with the elimination of useless species. As each felling cycle comes round, more funnels would be made in the area, and it is hoped that an un-even aged crop of mixed valuable species would ultimately be obtained, to the exclusion of the useless species.

NOTE ON PAPER (*ii*) ABOVE.

By

A. A. F. MINCHIN, *Conservator, Working Plans Circle, Madras.*

Regeneration work, as contemplated in Mr. Laurie's note, would—if the method continues to prove satisfactory with further experience,—be applicable to mixed deciduous forest unfit for the " Clearfelling and planting " system, or any other more or less standard system: that is to say, to forest in which, for want of a better mode of management, we apply our " so-called Selection system ". We have no higher aim than this: after each cycle of fellings the introduction of small groups of the more valuable species will be ensured, to the exclusion of useless species that would otherwise be likely to fill the gaps. We believe the chances of the groups introduced will be better if a Forest Guard of the local jungle-tribe is given their care and tending as his sole duty.

NOTE ON FOREGOING PAPER (*ii*).

By

E. G. GARLAND, *Divisional Forest Officer, W. Nasik, Bombay.*

A short note on very similar work carried out in West Nasik Division of the Northern Circle, Bombay Presidency, may be of interest. These forests are very inaccessible and teak is the only species for which there is a market, and in the past only the very best grown and soundest of the teak also have been exploited since everything else was unremunerative. In consequence there is a considerable quantity of over mature or unsound teak in all the more accessible areas though in the remote blocks there are some fine stands of excellent timber. The whole area is now being gradually opened up by roads and a treatment by selection combined with improvement fellings and thinnings has been prescribed. Our marking therefore consists of—

(*a*) Teak of exploitable size.

(*b*) Unsound, suppressed and malformed teak unlikely ever to reach the exploitable size.

(3) Any trees of other species interfering with the growth of promising teak of all sizes.

Felling is done between October and March departmentally. The labour employed is divided into three main gangs. First the actual felling party of men. Then behind these another party of men who do the rough conversion of the felled timber so that all useful timber is ready for dragging out by

pairs of buffaloes. This work of course includes cutting off all branch-wood from the main stem. The third gang works immediately behind the 2nd and consists of women and boys who collect all the branch-wood and lay it into "rabs" in any suitable spaces. These spaces mostly occur as pointed out by Mr. Laurie where the crowns of felled trees have fallen. This is an advantage since the teak stumps are left free to the sides of the rabs to regenerate by coppice shoots.

The sites selected for the rabs are roughly pegged out by the Range Forest Officer in charge of the whole felling work. They naturally vary very greatly in size, but are not smaller than 20′ × 20′ and often very considerably larger. Spaces which were open even before felling are also treated in the same way and the branch-wood is augmented by cutting shrubs and bamboo if necessary.

At the time of laying rabs all fallen logs are removed to the sides of the selected sites as their presence in a rab has been found to interfere with an even burn. The advantage of preparing the rabs immediately felling has taken place is that thereby all leaves are taken with the branch-wood to increase the material for burning before they have had time to wither and fall off. Rabs ideally consist only of small branch-wood laid fairly flat with the stems all pointing in one direction. After laying the rab may be 4—5 feet thick. If expenses permit however this is beaten down after the branch-wood has dried and compressed to about 2′ thick. It may then also be covered with a layer of grass and earth, the object being to obtain as slow and even burn as possible and not a sudden scorching blaze.

The burning is done in April. If the ash is too thick it is scrapped off to the sides of the rab before sowing which is carried out with treated seed in May.

Two weedings are required, one in August and the 2nd in October. One weeding in the 2nd year is also sometimes required.

It has also been found that it is necessary to go over the regenerated areas after the first rains and remove a certain number of trees at the edges of the rabs which have either been scorched and killed by the heat of the burning or which have thrown out a thick crop of epicormic branches from the same cause augmented by the opening of the canopy.

NOTE.

By

H. L. NEWMAN, *Chief Conservator of Forests, Bombay Presidency.*

Beginnings have been made in regeneration work of the kind referred to by Mr. Laurie, in teak bearing High Forest in the Southern Circle of Bombay, where the silvicultural method of treatment is that of Selection and Improvement Fellings combined, or either of these methods alone. Experience of many years has shown that regeneration of teak is very rarely, if at all, secured by leaving things to nature in forests worked under this system. At the same time much of our finest teak bearing forest in North Kanara is so situated as to render its working under clear fellings both unsuitable and impracticable. Our only hope is to make use of the gaps created by the fellings and to burn over the debris (it may be by burning whole compartments), introducing the teak afterwards by dibbling and planting. Within the very limited area so operated on hitherto in Bombay the results are distinctly encouraging, and justify some confidence in feeling that the method is one (and possibly the only one) which will produce a new healthy stock of teak under the conditions most favourable to it, conditions in fact under which nature displays teak at its best and intended that it should grow.

* * * * * * *

REPORT OF DEBATE.

Mr. Rowbotham: According to notes received from Messrs. Newman, Garland and Laurie, experiments in artificial regeneration in funnels in

mixed deciduous forest in the Northern Circle, Bombay, and at Mount Stuart in Madras, indicate this method as being the only suitable one discovered there up to date, in remote areas where clear fellings are impracticable. Teak is the favoured species, and it is mentioned that in Bombay regeneration of teak is very rarely, if at all, secured by leaving things to nature in forests worked under the Selection System, and that burning collected debris under gaps created by the fellings followed by dibbling and planting teak and other species, has given distinctly encouraging results, and it is hoped to produce a new healthy stock of teak and other valuable species under the conditions most favourable to their growth.

It appears that intensive burns on small patches render the soil unsuitable for germination and that a slow even burn of small sized debris well distributed throughout the felling area is one of objects to attain. The expenditure in Madras varies from Rs. 3-8-0 to Rs. 1-11-0 per patch, and if the method is carried out on a large scale may possibly approximate Re. 1 per funnel for the first season.

In Bombay the general height growth of the forest is apparently sufficiently low to permit of raising an extreme light demander like teak in gaps of moderate size.

To what extent this method is applicable and capable of control over large areas is a matter for local officers, after further experiments, to decide.

In Assam, observations have been made this year in two types of forest, one moist mixed containing light demanders, and the other, evergreen with shade-bearers. It seems that Artificial Regeneration with Selection Felling should be applicable to the better stocked forests in the Sadiya Frontier Tract where *Terminalia myriocarpa* is the principal species. Dense patches of natural regeneration accompanied by seedlings of *Cedrela Toona* and *Morus laevigata* are observed to occur wherever the soil is uncovered and broken by felling large trees and dragging out logs, and there would be no difficulty in augmenting this regeneration by cutting and burning undergrowth in patches beneath wide gaps in the overhead canopy and sowing *Terminalia* seed on them broadcast. Where there is a preponderence of overmature stems, the gaps created are of considerable size. Burning is not severe or able to spread in these moist mixed forests as in Bombay. *Terminalia* regeneration has been observed to survive suppression by weeds during the first rains, but to be gradually killed off during 2nd and 3rd rains if no weeding is done. The first weeding of patches of natural regeneration has been done for Rs. 3 per acre over 200 acres, and it is proposed to weed again in the 2nd and 3rd year after the rains.

As regards shade-bearing species in the best stocked evergreen Dipterocarp forests in the hills of Lakhimpur Division, abundant natural regeneration of the Dipterocarps and of *Mesua* is frequently found on the ground prior to selection fellings. In coupes exploited from 2 to 4 years ago and not given any subsequent treatment, most of such regeneration seems to be gradually succumbing to heavy weed growth and inferior fast growing species, especially where the first felling of overmature stems has been heavy and has let in a considerable amount of light.

Subsequent to removal of overmature stems under the Selection System, dibbling in seeds of *Dipterocarps* and *Mesua* in patches of ground freed of weed growth is recommended underneath any existing stands of inferior miscellaneous species, but the principal treatment required is cutting of climbers throughout before felling, and annual or biennial cutting of weeds in the cold weather, as well as careful regulation of the fellings to prevent large gaps from being created in the overhead canopy.

Experimental plots established this year aim at raising plants to the sapling stage by periodic weeding, and later, from the sapling to pole stage by thinning or girdling inferior species in the overwood and underwood. The cost of cutting climbers and of nearly all weed growth throughout these plots this year was about Rs. 5 per acre. The cost would be reduced if later on it was practicable to do the weed cutting on a less extensive scale.

Mr. Garland (Bombay) : I don't want to say anything beyond what has already been said, except that this particular method that we have started in Bombay is still extremely in the experimental stage, and is really a large modification of our technique. We have only done a little work in this direction on account of the difficulty in getting the necessary funds.

Mr. Shebbeare : In Bengal we were frightened to see the whole ground covered with weeds. The idea was to have cut large trees and to replace them by the plants from the nursery. Unfortunately in most of the places no results at all were obtained.

Mr. Blanford : I personally have no faith in artificial regeneration in selection forests. We have wasted lakhs of rupees on such artificial regeneration and I don't believe a single plant has come through. For some time back we have been alarmed by the prospect of flowering of *kyathaung* (*Bambusa polymorpha*). We made some experiments. The idea was to cut out suitable gaps in *kyathaung* forest, and sow teak seed. The seedlings mostly died after one year, and the work was very expensive. A few teak occasionally survived for few years and then the bamboo came in again. I think from the financial point of view it is going to be very costly to make this work a success.

Chairman: I think in the United Provinces a great deal of work was done in the patch sowing of *sal* which was invariably a failure.

Mr. Smythies : We did do patch sowing, and though something came of it locally, it must be admitted that it was not much.

Mr. Glover : We have certain amount of experience in the Punjab with the artificial regeneration under selective system in mixed forest of fir and deodar. 20 years ago we became very much dissatisfied with what was going on in the regeneration. We had to retain the selection system in mixed forests with deodar on steep ground or in remote localities. We are not getting natural deodar regeneration there. I am referring to the Selection System as I understand it, *i.e.*, the European Selection System. We certainly have got a certain amount of success by this method.

Mr. Sher Singh : We too have done some work in Kashmir. I am referring to the Selection System as I understand it, *i.e.*, the European Selection System. We also have got a certain amount of success.

Chairman: It seems to me that the whole question of obtaining success with artificial regeneration under the Selection System in mixed forests is most difficult and mostly is a record of failures. Artificial regeneration is generally not worthwhile. On the other hand with just the right conditions it might be a great success. I don't think we can dogmatize on the subject.

ITEM 11.

REVISION AND COMPILATION OF THE STATISTICAL CODE.

General.

A draft revision of the code as regards field work for volume and yield tables was prepared in the Statistical Section of the Silvicultural Branch of the Forest Research Institute (*vide* page 148). Mr. Chaturvedi (United Provinces) presented a paper advocating the adoption of the diameter tape in place of callipers *vide* page 156, and suggesting some amendments to be made in the current code, *ride* page 162. Mr. Shirley (Burma) sent in a note, *vide* page 162, on the subject of small wood measurements, pointing out that a recommendation of the last Conference on the subject had not been carried out.

Short notes and comments were sent in by Assam, Bihar and Orissa, Burma, Kashmir and the United Provinces.

In Committee (Experimental and Statistical Committee), the Central Silviculturist first summarised the opinions and suggestions received, with reference to his revision.

The question of adoption of the diameter tape was then debated at some length, the advantages of the tape being admitted in a general way, but the feeling being strong that having changed once from tape to callipers, it would be unwise to change back again unless some very definite advantage was obtained. The Central Silviculturist circulated a note (*ride* page 160) on a comparative field test with the two instruments. A division was called for, and representatives of Bengal, Burma, Central Provinces, Punjab, Kashmir and the North-West Frontier Province voted against the tape, and those of the United Provinces and Assam for it (Assam on account of the large average diameters dealt with), whilst the Bihar and Orissa Silviculturist and the Central Silviculturist remained neutral.

The 'surround' of sample plots was again discussed, and experience of the practical difficulties and objections to any fixed width was referred to by several members.

The best method of grouping diameters in Sample plot calculations was discussed, but in view of lack of unanimity, no change was proposed. There was also some discussion as to how to derive crop height for calculating volume, for allotting a plot to a quality class, and for divisional use of yield tables. Alternative methods of delimiting quality classes were described by the Central Silviculturist and their merits debated.

The Committee presented a report to the Conference which is reproduced below with the resolution. There was no further debate.

The following resolution was proposed by Mr. Champion and seconded by Mr. Howard, (United Provinces), and carried:—

* * * *

Resolution 11.

Resolved *that the report of the Committee be accepted.*

* * * *

Report of Committee.

The Committee considers that a new Code is required. It should keep to the prescriptions of the existing Code except in so far as these have been modified by general agreement. It should be composed of the necessary number of sections each dealing with the whole of a subject, *e.g.*, one for sample plot work, one for stump analysis, one for volume tables, and so on. Each section should be in two parts, field work clearly separated from office work. The general method of presentation of the Central Silviculturist's paper (*cf.* page 148) was approved.

The relative merits of the diameter tape and callipers were discussed and the large majority of the Committee was in favour of continuing the use of

callipers on the grounds that a change is undesirable unless some very distinct benefit is to be gained.

The following alterations in the Central Silviculturist's proposed procedure are recommended. (*Cf.* page 149 *et seq.*)

Omit I 4 (*b*), page 150.

To I 4 (*d*), page 150, *add* " To keep the corrections small, the tree should be felled as low as possible ".

To II 1 (*g*), page 151, *add* " The surround should equal the height of the crop at the time of laying out the plot, but should not be less than 12 yards ".

II 2 (*c*), page 152, *add* " whenever the average slope exceeds 10° ".

II 4 (*a*), page 152, *add* " or may be replaced by intermediate posts smaller than the corner posts, at about 20′ intervals ".

II 4 (*c*), page 152. *Omit* the words " and the year of laying out ".

II 7, page 153, *add* a clause " If paint numbers are inadequate and the use of a nail is necessary to carry a number tag, it should be inserted 18″ above the cross mark ".

II 9 (*b*), page 153, after " classified ", *add* " especially the central group or groups ".

Replace the last sentence by :—

" Not less than 6 sample trees should be selected and measured, and 12 properly selected are usually enough ".

II 10, page 154, *add* as a new clause after (*a*) :—

" Branch small wood will in future only be measured for species other than *sal*, teak, deodar, *chir* and blue pine ".

Add 10 (*e*) :—

It is useful to record the diameter under bark at the point midway between breast height and the top of the tree to permit the calculation of form quotient.

II 13, page 155. The period of measurement was discussed and the Central Silviculturist's recommendation accepted.

II 14 (*b*), page 155. The letter indicating the grade of thinning should always be prefixed to the sample plot number. Hence omit the second sentence.

II 14 (*d*) and (*e*) were discussed and it was decided to retain the Central Silviculturist's recommendations as they were purely permissive.

Yield Table Compilation.—Crop height was discussed and it was decided not to alter the present procedure, but the question of changing to " Dominant " height should be investigated by the Central Silviculturist in consultation with Provincial Silviculturists and other officers.

The Central Silviculturist's recommendation that the method of delimiting quality classes by taking a convenient fixed height range at a fixed age (preferably about the usual rotation age) for each quantity, as done in the blue pine yield tables now in the press, is accepted.

PAPER (*i*)

Contributed by

H. G. CHAMPION, *Silviculturist, Forest Research Institute*

and

ISHWAR DAS MAHENDRU, *Statistical Assistant.*

Since Mr. Howard wrote his " Code for the Collection and Tabulation of Statistical Data " in 1921, experience has made it apparent that some of the details require amendment, and that some sections could usefully be expanded. Actually the Code deals fully with the Sample Plot in even-aged normal crops, and does little more than enumerate—with very brief notes—the other aspects of our statistical work, the necessity for further elaboration being foreseen.

Some *addenda* and *corrigenda* to the rules for Sample Plot work were dealt with at the 1922 Silvicultural Conference, and others will probably be proposed at the present Conference. It therefore appears desirable that a new Code should be compiled, bringing up to date the procedure for sample plots* and completing the account for other classes of data, *viz.*, stump and stem analysis, increment of species without rings, and, if thought advisable, methods of compilation of volume and yield tables, as also of statistical research on the effect of different grades of thinning.

The present note collects in a revised form the rules for the measurement of trees and crops as required in the field by a sample plot or volume table party, and in so far as it is found acceptable, would be incorporated in a new Code if one is to be written.

I.—General Rules for Measurement of Trees.

1. *Breast height.*

(*a*) Breast height should be measured by means of a measuring stick on the standing tree at 4′-6″ above ground level.

(*b*) On sloping ground, breast height should be measured on the uphill side, after removal of dead leaves and needles lodged there.

(*c*) The breast height point should be marked by intersecting vertical and horizontal lines (5″ long whenever possible) painted with white paint. This is referred to as the cross-mark.

(*d*) Breast height measurements should not be taken at 4′-6″ if the stem is abnormal at that level, but the cross-mark should be shifted up or down as little as possible to a more normal portion of the stem.

(*e*) When buttress formation is characteristic of a species, and is known or is likely to extend upwards with development of tree, the cross-mark should be painted at the lowest level above which abnormal formation is not likely to extend. This height must be standardised for the species, and the relationship between diameter at breast height and at this standard height must be separately worked out if required in divisional practice.

(*f*) The height above ground level of the cross-mark should always be recorded for each tree measured.

2. *Diameter measurement.*

(*a*) When callipers are used, two measurements should whenever possible be taken at right angles to each other. Diameter is then understood to imply the average of the two measurements.

(*b*) Before taking over-bark measurements, climbers, moss, lichen, and loose bark should be removed by hand or with a rough stick.

(*c*) Diameter at breast height should be measured at the cross-mark on the standing tree.

(*d*) Under-bark measurements should be taken after removing a narrow strip (3″-4″ wide) of bark all round the stem, care being required to ensure that the bark is entirely removed but none of the outer wood with it.

(*e*) Diameter should be measured and recorded in inches and decimals to the nearest tenth.

3. *Height measurement.*

(*a*) Total height should be measured from ground level to the tip of the leader, or to the highest point above ground level when no leader exists.

(*b*) The total height of a felled tree should be measured by tape in a straight line, no allowance being made for the curvature of stem or any other defect. (The stump must be included).

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*It will probably be found desirable to keep the Sample Plot sections entirely separate, so that the existing Code would be revised with elimination of all other matters, the latter being dealt with in a second volume.

(*c*) Total height should be measured to the nearest whole foot, half or more being counted as one.

4. *Age.*

(*a*) For species with annual rings, age should be determined by counting the rings on the stumps.

(*b*) When the rings at the centre are crowded so as to be indistinguishable, the age for this portion may be estimated by drawing an age/diameter curve for the later normal growth, and extrapolating to cover the period of abnormal growth.

(*c*) The height of the stump should be measured from the height of the point at which the pith is cut, to the average ground level at which it may be assumed the seedling started growth.

(*d*) The number of years required for seedlings to reach stump height should be determined by measurement of seedlings growing under similar conditions. Free growing seedlings should be selected for this purpose, and the data should be standardised for each species, quality, class and method of regeneration.

5. *Timber and Smallwood.*

(*a*) Timber volumes should be measured under bark with full sectional area (π r^2).

(*b*) Smallwood should be measured as volume over bark with full sectional area (π r^2).

(*c*) All length measurements should be made to the nearest whole foot.

(*d*) Standard timber comprises the volume, including stump but excluding bark, down to the limiting diameter of 8″ over bark.

(*e*) Standard smallwood comprises the volume, including bark, between the limiting diameters of 8″ and 2″ over bark.

(*f*) Standard timber bole should be measured in a straight line from ground level up to 8″ diameter over bark. (In practice the cross-mark provides a datum point for taking this measurement on the felled tree).

(*g*) Standard timber and smallwood volumes of the branches, when required, should be measured and recorded separately from those of the stem.

(*h*) Stem timber and smallwood volumes of the felled tree should be measured by dividing the total length of each into as nearly as possible equal sections, and by taking the following measurements:—

(*i*) Length of each section.

(*ii*) Under-bark diameter at the middle of each timber section.

(*iii*) Over-bark diameter at the middle of each smallwood section.

(*i*) Timber and smallwood in branches should be dealt with in the same way when branchwood data are required.

(*j*) Timber and smallwood sections should be measured straight from end to end, no allowance being made for curvature, hollowness or any other defect except as additional data when specially called for.

6. *Standard measurements.*

(*a*) Standard measurements include the following:—

(*i*) Diameter at breast height over and under bark. (§ 2).

(*ii*) Total height to the nearest whole foot. (§ 3).

(*iii*) Standard timber bole length. (§ 5).

(*iv*) Length of timber sections preferably 10′, (odd feet being included in the last section which should not exceed 15′), and diameter under bark at the middle of each section, separately for stem and branches. (§ 5).

(*v*) Length of smallwood sections (sub-division as for timber) and diameter over bark at the middle of each smallwood section, separately for stem and branches. (§ 5). Dead branches are not measured.

(*vi*) Diameter over and under bark at half total height. (§ 2).

(*vii*) Ring countings on the stump, and the height of cut pith above average ground level. (§ 4).

(*b*) When callipers are used, fixed iron callipers of 8″ and 2″ diameter may be used with advantage to locate timber and smallwood limits on a felled tree.*

7. *Commercial measurements.*

(*a*) Commercial measurements include the following:—

(*i*) Diameter at breast height. (§ 2).

(*ii*) Total height to nearest whole foot. (§ 3).

(*iii*) Commercial timber bole length from the butt as far up as the wood is utilised, or to any limit accepted for this purpose.

(*iv*) Diameter over bark at the thin end of the commercial bole.

(*v*) Length of timber sections (as nearly as possible equal and not exceeding 20′) and diameters under bark at the middle of each section. (§ 5).

(*vi*) Diameter over and under bark of the middle of commercial bole.

(*vii*) Ring counting on the stump and the height of stump, together with an estimate of the quality of the locality based on any accepted standard. (§ 4).

(*b*) The following treatment of forked trees should be followed:—

(*i*) Trees forked below 12′ should not be measured.

(*ii*) For trees forked below the living crown, the larger arm should be treated as the stem, and the volume of the other arm should be recorded separately from the branch-wood.

II.—Rules for Measurement of Permanent Sample Plots in even-aged Normal Crops.

1. *Selection of plots.*

(*a*) Plots should be selected in crops of all ages, and should be well distributed over the whole range of quality, types, and geographical distribution of the species.

(*b*) To ensure adequate distribution of plots over qualities, a height/age diagram should be plotted after laying out the first few plots, and used as a guide for selecting further plots.

(*c*) Plots should be laid out in even-aged crops, the conception even-aged being interpreted with reference to the customary regeneration period for the species.

(*d*) Plots should be selected as far as possible in fully stocked crops. (No allowance should be made for incomplete stocking).

(*e*) When owing to a lack of fully stocked crops, plots have to be laid out in open crops, the stocking should be as uniform as possible, large gaps and patchy growth being avoided.

(*f*) The boundary should be so selected as to avoid trees at the edge of a crop or with crowns spreading into an adjacent large gap.

(*g*) Whenever possible, plots should be provided with a surrounding strip (the 'surround') to be treated in the same way as the plot. This strip should be of sufficient width to provide the necessary sample trees unlikely to be obtainable from the plot itself; it should not be less than 12 yards wide and

* *N.B.*—The limit of 8″ *average* diameter has to be located.

should be demarcated by painting white rings at breast height on the outermost trees.

(*h*) Whenever an area which has been selected as suitable for laying out plots is large enough for making a pair or set of plots with the same initial conditions but with different kind or grade of thinning, such a pair or set of plots should be laid out on the accepted lines.

2. *Shape of Plots.*

(*a*) Plots should always have rectilinear boundaries with the angle between any two sides not less than 30°. Pronounced re-entrant angles should be avoided.

(*b*) The sides of a plot, and the necessary number of diagonals to divide it completely into triangular portions, should be measured by tape to the nearest whole foot, the shortest diagonals being taken by preference.

(*c*) The slopes of sides and diagonals should be measured by means of an Abney's level, or any other instrument of equal precision.

(*d*) The actual measurements of sides and diagonals and their slopes should be recorded on a diagrammatic sketch map for purposes of calculation of area.

(*e*) A detailed map shewing position of trees should be prepared when practicable.

3. *Size of Plots.*

(*a*) Plots should as far as possible be half an acre or more in area. Smaller area is of less importance in the case of small trees, but may prevent maintenance of the plot after a few remeasurements. Above half an acre, uniformity of stocking and availability of sample trees is more important than larger area.

(*b*) 25 dominant trees may be taken as an absolute minimum for maturing and mature crops.

4. *Demarcation.*

(*a*) The boundaries of the plot should be marked by means of trenches, approximately one foot wide by one foot deep. Where erosion is to be feared, these may have to be omitted.

(*b*) The corners of the plot should be marked by means of durable wooden posts serially numbered. Where suitable posts are not available, masonry pillars should be erected.

(*c*) The number of the plot and the year of laying out should be indicated on a board or enamel plate fixed in any convenient and conspicuous position near or in the plot.

(*d*) The boundaries of a plot should be so placed as to coincide as far as possible with the outer limits of the projected crowns of the marginal trees.

5. *Thinnings.*

(*a*) The kind, grade and frequency of thinning to be done should be recorded in the file, and strictly adhered to. A copy of the thinning scale adopted (*e.g.*, Forest Bulletin 52, 1922) should be appended to these rules.

(*b*) As far as possible the plot should be brought into a normal condition when first laid out, but overstocking may take two or even three thinnings to adjust.

(*c*) Thinnings should normally be made when the plot is laid out, and thereafter at 10-year intervals, except that:—

(*i*) For over-stocked plots which cannot be brought to a normal condition when first laid out, the second interval should be 5 years if the condition of the crop allows.

(*ii*) With young crops of such species as are thinned 5 yearly in divisional practice, this period may be adopted for as many intervals as customary or desirable.

6. *Painting cross-mark.*

(*a*) All green trees which are included within the limits of a plot, and the measurements of which are to be recorded, should be painted with a cross-mark at 4′-6″, except that :—

(*i*) When the bole is abnormal at 4′-6″, the height of the cross-mark should be altered as in General Rule 1 (*d*).

(*ii*) No tree under 2″ d. b. h. should be cross-marked.

(*b*) The cross-marks should be on the uphill side on hilly ground, and all facing the same way in plots on level ground.

7. *Numbering.*

(*a*) All trees forming part of the principal crop should be serially numbered, except that until the smallest trees in the main canopy reach 4″ diameter, no numbering will be done (but only enumeration).

(*b*) The numbers should be on the same side of the tree as the cross-mark, and are conveniently painted above a line 6″ above the breast height point.

(*c*) The outer dead bark may be carefully trimmed off with a sharp instrument to give a smooth surface for painting, but great care should be taken that no living tissues are injured or exposed.

(*d*) On hilly ground, numbering should start from above and should proceed stripwise along contour lines; on level ground, numbering should run in strips parallel to one side of the plot.

(*e*) Where a second storey is distinguished, whether of the same species as the top storey or not, the trees should be similarly numbered, preferably continuing the sequence of the principal crop, and it should be clearly stated on Form 3 which numbers belong to the understorey.

(*f*) When once numbering is done, all trees must be numbered.

8. *Measurement of standing crop.*

(*a*) Breast height diameter should be measured on all trees painted with cross-marks.

(*b*) The diameters of trees marked for thinnings should be separately recorded in Form 3 in the column provided for the purpose.

(*c*) In crops of small trees not numbered, the results of enumeration in 1″ diameter classes should be recorded on Form 3.

(*d*) Crown class on the standardised scale should be recorded for every tree for which diameter is separately recorded. *Vide* Appendix I.

(*e*) Crown classes of trees should be judged *after* felling the thinnings.

9. *Selection of sample trees.*

(*a*) Sample trees should in the first place be selected out of the thinnings marked in the plot; thinnings should not be felled until sample trees have been selected.

(*b*) Enough sample trees are needed for drawing the height/diameter curve with requisite accuracy over the greater part of the diameter range of the crop, in particular, the parts of the curve corresponding to the mean diameters of the groups in which the trees will probably be classified. Not less than 6 or more than 12 sample trees should be taken and measured.

(*c*) If the necessary sample trees are not available from trees marked for thinnings in the plot, the rest may be selected in the surround. Only in cases of absolute necessity should one go beyond the surround for sample trees.

(*d*) A sample tree of a given diameter should be representative of its diameter class in height, form, and crown development.

(*e*) In view of the ever increasing difficulty of obtaining suitable sample trees from fellings in the plot and surround, measurement of standing sample trees is recommended whenever practicable.

(*f*) Stem analysis on standard lines of about 5 of the sample trees is recommended particularly at first measurement, as supplying data concerning the past growth of the plot not otherwise obtainable. The trees analysed should be of somewhat above the mean diameter.

(*g*) Additional height measurements of typical standing trees of the main crop may be of considerable help provided the accuracy of the measurement is known, as may be ensured by taking the height of some of the sample trees with the same instrument before felling.

(*h*) A separate set of sample trees should be selected for a subordinate species when it comprises more than 20 per cent. of the total number of trees, and has a place in the main canopy.

(*i*) If more than 12 trees are felled as thinnings, eight or more of them should be measured as sample trees as described under 9 (*b*) above.

(*j*) If the volume of the understorey is required, a separate set of sample trees should be measured for it.

10. *Measurements of sample trees.*

(*a*) Standard measurements in πr^2 units as listed under General Rule 6 should be taken on all sample trees.

(*b*) Measurements of sample trees should be recorded in Form No. 7.

(*c*) Where well established local standards of conversion and utilisation exist, the volume of sample trees should also be measured on these standards.

(*d*) It is useful to record the average length of the green crown as reflecting the density of the crop. Crown length is measured from the tip to a point midway between the lowest branch with green leaves, and the lowest point at which the crown is developed on all sides of the bole.

11. *Measurement of thinnings.*

(*a*) Standard measurements should be recorded for all trees felled as thinnings if they do not exceed 12 in number.

(*b*) If more than 12 trees are felled in the plot, eight or more may be selected as typical and measured as sample trees for thinnings only. Trees accepted as samples for the main crop will often not be suitable as samples for the thinning, particularly with light thinnings.

12. *Description of the plot* (Form 2).

1. *Area* is not required to be recorded in the field. (Entry 2).

2. *Situation* as regards the forest block and compartment, the Rest House or customary camp from which the plot is inspected, and the road or path by which it is approached, should be noted. (Entry 3).

3. Under Climate should be recorded (*i*) the annual rainfall and its distribution, (*ii*) winter conditions, (*iii*) hot weather conditions. (Entry 6).

4. *Type* of forest (Entry 8) should not be confused with condition. (Entry 16).

5. Description of the *undergrowth* should be adequate without becoming profuse. Standard abbreviations for frequency should be used (*vide* A. G. Tansley, Practical Plant Ecology, page 92: *va* = very abundant, *a* = abundant, *f* = frequent, *o* = occasional, *r* = rare, *vr* = very rare. A prefix *l* may be used to indicate that the frequency is local only, but this will rarely be required in sample plots). The relative abundance of grass and herbage should be mentioned, as well as the shrubs. (Entry 9).

6. Under *Condition of crop* should be recorded notes on the density and uniformity of stocking, appearance as regards quality of boles, general healthiness and whether much grazed, fire damaged, etc. (Entry 16).

13. *Remeasurements.*

(*a*) Remeasurement of plots should be done at 10-year intervals, except that full measurements will always be made when a thinning is done (*vide* Rule 5 (*c*) above).

(*b*) Remeasurements should be done as far as possible in the season of vegetative rest.

(*c*) All measurements prescribed for the first measurement should be taken at a full remeasurement.

(*d*) If after a 5-year interval, a full remeasurement is not due, an *interim* measurement should be made recording—

(*i*) Diameters of all standing trees.

(*ii*) Height of selected standing trees.

The following rules (*f*) and (*g*) will also be followed :—

(*e*) For trees with annual rings, the length of the leading shoot put on since the date of the last measurement should be found by cutting off the top in short sections till it shews a number of rings equal to the number of years which have elapsed. It should be recorded in feet, correct to one place of decimals, from the beginning of the growth of that year.

(*f*) The cross-marks and numbers should be repainted.

(*g*) The boundary trenches and corner posts should be repaired as required.

(*h*) The sides and diagonals of the plot should be remeasured by way of check, and any discrepancy observed should be recorded on Form No. 2 (contd.)

14. *General.*

(*a*) The plots should be serially numbered for each division separately.

(*b*) The grade of thinning must be prescribed for every plot and should be indicated by the corresponding letter before the plot number (thus B 63 means sample plot No. 63 to be thinned on B grade). The usual thinning to be applied is the C grade ordinary thinnings, and for convenience, the letter C should be omitted except when the distinction is required as in a series of thinning plots. Crown thinnings should be given the distinguishing prefixed letter, L for the light grade, and H for the heavy.

(*c*) A definite lower storey, where present, should ordinarily not be removed where this is likely appreciably to alter the silvicultural conditions under which the principal crop is growing.

(*d*) When the lower storey is composed entirely of subsidiary species and nowhere interferes with the main canopy, it need not be cross-marked or numbered, but an enumeration by species in 1″ diameter classes is useful as providing a numerical expression of the amount and composition of such understorey.

(*e*) When trees of the principal species, or of species represented in the main canopy, are relegated to the lower storey, they must be cross-marked and numbered, the foregoing rule (*d*) still applying to any subsidiary species present.

(*f*) Undergrowth should not be cleared more than is necessary to facilitate the work of measurement.

(*g*) The general treatment of the plot as regards fire protection, burning, grazing, grass cutting, etc., should, unless there are special reasons to the contrary, be the same as for the surrounding forest.

15. *Field Equipment.*

(1) Adjustable callipers, two large (32″) and one small (14″), and 2 fixed iron callipers of 8″ and 2″, *or*, 2 steel diameter tapes (about 15′ long).

(2) 100′ and 50′ cloth tapes graduated in feet and inches, one of each.

(3) Steel tape—1 (about 12′ long).

(4) Tree-scribe—1.

(5) Felling axes—6.
(6) One small axe (sharp, for cleaning stumps for ring counting).
(7) Abney's level.
(8) Surveyor's rods—4.
(9) Surveyor's cross stave—1.
(10) Field note books.
(11) Sample plot forms 8, 3, and 7 bound in books.
(12) Section paper.
(13) Chalk (1 lb. per 100 trees).
(14) White paint, 5 lbs. and $1\frac{1}{2}$ lbs$\frac{1}{2}$. linseed oil$\frac{1}{2}$ per 100 trees.
(15) Plane table if required for mapping position of the trees in the plot.

* * * * *

PAPER (*ii*)

Contributed by

M. D. CHATURVEDI, *Silviculturist, United Provinces.*

Foreword.

Mr. Howard's Code, providing as it does, a working basis for the statistical work in India, has, on the whole, worked extremely well in actual practice during the last seven years. To its credit may be mentioned several yield and volume tables and, above all, its biggest achievement is the standardisation of sample plot work all over India.

In the light of experience gained in India and elsewhere in statistical work, certain modifications of the Code are indicated. In the following pages I have offered necessary amendments to the Code which, if accepted, will bring it in line with the latest methods employed in Europe and America in dealing with the statistical research in forestry.

4. MEASUREMENT OF PERMANENT SAMPLE PLOTS IN EVEN-AGED NORMAL CROPS.

A. Regular Crops.

Substitute (4) by :—

The diameter of a tree at breast height should be measured by tape and not by callipers. All calliper measurements in permanent sample plot work should be discontinued. A diameter tape may be used for this purpose with advantage.

N.B.—Effect this correction throughout the Code.

1. Assuming the cross section of a tree to be elliptical and a and b its semi-major and minor axes then—

(1) the true basal area would be . . . . $= \pi ab$
(2) the area according to the formula $\pi \left(\frac{a+b}{2}\right)^2$. $= \pi ab + \frac{2}{3^2} k$
(3) the area according to the girth . . . $= \pi ab + \frac{3}{3^2} k$
(4) the area according to the formula $\pi \left(\frac{a^2+b^2}{2}\right)$. $= \pi ab + \frac{4}{3^2} k$

where, $k = e^4 (1 + \frac{1}{2} e^2) \pi a^2$ and $e^2 = \left(\frac{a^2-b^2}{a^2}\right)$.

Thus, the formula (4) which is recommended in the Code involves the largest error, greater even than the girth formula. And although the formula (2) attains the closest approximation to the real basal area, the actual measurement of the dimensions a and b by means of a pair of callipers is attended with serious difficulties.

2. A comparison of the errors involved in the girth and the diameter measurements by a tape and a pair of callipers respectively, shows that the

latter is more susceptible to errors. The following table (1) gives the nature and the extent of errors involved in the two instruments:—

Tape.	Callipers.
1. *Errors due to displacement of the tape from the horizontal.*—This is not very serious. For a displacement of as much as 10 degrees, the error involved in the basal area is only 1·6 per cent.	1. *Errors in the orientation of the major axis, i.e., the measurement of 2a.*—It is impossible to locate the major axis in the tree and the diameter usually measured and supposed to represent *2a*, involves errors in the basal area in the negative direction. This error is a direct function of the eccentricity of the ellipse. That is, the larger the difference between the two diameters, the larger the error.
2. *Errors due to stretching of the tape.*—This is negligible if a steel tape is used.	2. *Errors due to a variation of the angle between 2 diameters from a right angle, i.e., errors involved in the orientation of the minor axis (2b.).*—The maximum error is introduced if the angle between the two diameters is 45 degrees. If the two diameters of a tree are 20 and 18 inches respectively then the maximum error in the basal area due to this source alone is 5·9 per cent.
3. *Errors due to expansion.*—This again is negligible. This error is common both to the calliper and the tape.	3. *Errors due to the sliding arm being not at right angles to the scale.*—To insure the perpendicularity as well as the easy movement of the sliding arm is a difficult task. It is difficult to secure one condition without sacrificing the other. If the sliding arm deviates even by 2 degrees from a right angle the error in the basal area would be 3·4 per cent. This also is usually in the negative direction.
	4. *Errors due to the scale of the callipers not touching the tree.*—This will depend upon how far the scale is held from the tree. With an angle of error of 2 degrees in the callipers, if a tree of 20 inches in diameter is measured 15 inches from the scale, the error in the basal area would be 8·7 per cent. This is a fruitful source of error in calliper measurement due to the same cause.
	5. *Errors due to the deviation of the line of contract from the horizontal plane of the trees.*—For a deviation of 10 degrees the error in the basal area would be 3·01 per cent. which is about double the error involved in the girth measurements due to the same cause.

3. Again, for a given degree of accuracy in the basal area, the permissible absolute error in the measurement of the girth will be three times the absolute error in the diameter, since girth is approximately three times diameter. Thus, an error of 1 inch in the girth will cause the same error in the basal area as an error of $\frac{1}{3}$ inch in the diameter. Girth measurements have been claimed to ensure more consistent results than diameter measurements for successive volume determinations of a sample plot. It has been shown by Scherer (2) that the proportion between the error involved in measuring diameters and girths is as 21 to 1. The calliper measurements are unreliable unless the actual points where the diameters are to be measured are permanently marked and even then these errors, although they become systematic, are not entirely eliminated. The reason is not far to seek. It is extremely difficult to orientate the major and minor axes on a tree and to secure an angle of 90 degrees between them. This source of error accounts for the very inconsistent results obtained by various workers in statistical

forestry by repeating the calliper measurements. Marking the breast height point permanently on trees eliminates the errors due to the orientation of one axis only and to the extent that they become systematic at successive measurements. This, however, does not provide against the errors due to a variation of the angle between two axes from a right angle. Even a man checking his own diameter measurements on the same day gets a different result every time. Personal factors like fatigue and lack of enthusiasm also contribute towards making calliper measurements unreliable. There is always a perceptible difference between the calliper measurements carried out the first thing in the day and those carried out after the calliper man has worked for about six hours. A tired man does not drive the scale and the sliding arm home in to the tree. Calliper measurements, it will be seen, are subjected to various errors arising from a number of causes which can only be controlled by taking great pains and even then most of them could never be eliminated. The probability of the various errors in the calliper-measurements cancelling one another out has been advanced as an argument for the superiority of the callipers over the tape. As a matter of fact it is easier to standardise the errors of the tape, which are always in the positive direction, than the errors of the callipers which are unsystematic and more subject to personal factors. The girth measurements, apart from being subject to errors due to fewer causes than calliper measurements, have the advantage that they are simpler in practice, and dispense with the calculation of the mean of two diameters at right angles for each tree. The tape is also much cheaper than the callipers. The best of callipers, apart from being expensive, do not last for more than a year. In the case of felled trees it is easier to use a tape than callipers. The girth measurements do not involve any more time than the diameter measurements if two diameters at right angles are to be measured for each tree in a sample plot (3). There are no errors in the tape itself corresponding to the angle of error in the callipers, and the errors due to the non-horizontality are in magnitude approximately half those of the callipers. Nor does the question of the orientation of the axis or having a right angle between them arises with tape measurements. On the whole, the writer is inclined to believe that the determination of the basal area from the girth not only involves less elaborate and tedious calculations, but is also based on a more secure foundation than that derived from the calliper measurements. The security of the girth measurement lies in the uniform direction of its errors which can be systematized for successive measurements in a sample plot.

4. Researches of other authors relevant to the present discussion may also be briefly cited here :—

(*a*) The conclusions of Richard E. McArdle (3) based on diameter and girth measurements of Douglas Fir at Pacific Northwest Forest Experiment Station are :—

i. Each man fails to check himself by 0·42 per cent. of total basal area if the diameter tape is used, but with callipers the difference is 0·51 per cent.

ii. When one man checks another's measurements the difference involved is 0·09 and 1·40 per cent. of the total basal area according as the tape or the calliper is used. The average deviation was 0·2 and 1·3 for the tape and the callipers respectively. Trees were measured correct to a tenth of an inch.

iii. Measurement of 200 trees to one-tenth of an inch by both instruments required the same amount of time.*

iv. In four hundred measurements, tape results were 1·4 per cent. higher than callipers.

	Time required in minutes.	
	Tape.	Callipers
* 200 trees to tenth of an inch	65	64
200 trees to nearest inch	65	80

Two diameters at right angles were measured.

v. The tape is more consistent and should be used when the difference between two measurements of the same trees are of importance, as in measuring permanent sample plots.

(*b*) R. H. Candy, Dominion Forest Service (4), made a study of this problem to determine the relative accuracy of the two instruments; the dispersion in the measurements; the personal factor in their use. Twenty-one marked trees were measured one hundred times each with each instrument by two experienced men. Results were subjected to statistical analysis. The tape was almost consistently higher in results. The range of dispersion in the measurement of ten trees one hundred times by (A) with callipers was 0·16 inches; with tape 0·11 inches (B) callipers 0·14 inches; with tape 0·11 inches. The average difference between the measurements of A and B with callipers was 0·05 inches; with tape 0·005 inches. Hence when the diameter growth in a five year period is one-half inch, the callipers introduce an error (in the average) of ten per cent., the tape only one per cent.

His conclusions are that the tape measurements are uniformly higher, that the range of dispersion is greater with the callipers than with the tape, that the difference in the measurement by two men is greater with the callipers than with the tape. Hence the tape should be used for all permanent sample plot work.

(*c*) Herman Krauch (5) states that since the tape negotiates the whole circumference of a tree it measures the total growth whether put on uniformly or not, but the callipers indicate growth between the two points with which they are in contact and may not give any measure of the true growth at all. " It is, therefore obvious that the diameter tape should always be used when absolute accuracy is desired ". He, however, prefers callipers to a tape from considerations of speed (*c.f.* McArdle (a) *iii.*)

(*d*) E. F. McCarthy (6) is in favour of callipers because of speed and less liability to error. He gives no reasons for his belief that the callipers are less liable to error than the tape beyond pointing out the fact that the scale is less liable to be misread than the tape.

(*e*) Behre (7) reports that there is no significant difference between the two instruments. He worked in young crops and hence this conclusion.

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6. McCarthy, E. F. . . Comment on Tape and Callipers. *Am. Jr. For.* Vol. XII, 5 May 1924, p. 539. Washington, United States of America.
7. Behre, C. E. . . Comparison of Diameters Tape and Callipers in Measurements in Second Growth Spruce. *Am. Jr. For.* Vol. XXIV, 2 February 1926. Washington, United States of America.

Field Test for comparison of Callipers with the Diameter Tape.

By

Ishwar Das Mahendru, *Statistical Assistant to Central Silviculturist.*

1. *The object and basis of the investigation.*

To determine the relative consistency and accuracy of measurements obtained with the use of callipers and a diameter tape, measurements were made on two hundred *sal* trees in the Haldwani Division by two computers R. and S. Each computer measured the trees twice with callipers and twice with a diameter tape, 8 measurements of each tree, or 1,600 measurements in all, being thus obtained.

The point of measurement was marked beforehand on each tree by the usual cross mark; each computer used his own callipers, but only one diameter tape was available. With callipers, two measurements were taken at right angles to each other as usual.

2. *Consistency.*

The following checks of consistency were applied to the data so obtained:—

(*i*) *Aggregate basal area check.*—The aggregate basal area was calculated separately for each set of 200 measurements. The consistency of the measurements was then determined as the percentage difference between the aggregate basal areas calculated from any two sets of measurements which were sought to be compared.

The results may be summarised as under:—

Check.	Instrument used.	
	Callipers.	Diameter tape.
	Per cent.	Per cent.
Relative inconsistency between the successive measurements of the same individual, R. . .	0·16 } Average 0·09	0·10 } Average 0·08
Ditto do. S. . .	0·02 }	0·05 }
Relative inconsistency in average measurements by R., assuming S. correct	1·37 } Average 1·36	0·99 } Average 1·0
Ditto do.	1·35 }	1·0 }
Assuming R. correct	... ...	... ...

The results indicate very slightly more consistency with the use of the diameter tape, but it must be remembered that the tape was a new instrument to the recorders, which fact also account for the significantly different results as between R. and S.

(*ii*) *The grouping check.*—Successive measurements obtained with callipers and the diameter tape were grouped by 1″ classes, separately for R. and for S. As a measure of inconsistency, the number of trees differently

classified in successive measurements with the same instrument was then determined. The results may be summarised as follows :—

Nature of check.	Instrument.	
	Calliper.	Tape.
Inconsistency in grouping by R.	7 trees.	9 trees.
Ditto S.	10 „	2 „
Ditto between R's average and S's average	10 „	9 „

There is thus again a merely nominal difference between the instruments.

3. *Accuracy.*

The check of accuracy applied was to determine for each 1″ class, the percentage difference between the basal areas corresponding to the diameters obtained with callipers and diameter-tape respectively. As expected, the basal areas from the diameter tape measurements are consistently the higher. It is found that the percentage excess in the basal area averages 1·74.

4. *Comparison of the excess of basal area based on diameter tape measurements over the corresponding basal area based on calliper measurements.*

The conversion factor for girth into diameter is in the first place an index of the form of the cross section of the trees, particularly of the extent of their deviation from the circular cross section. The conversion factor in the case of the circular cross section is $1/\pi$ or 0·31831, and becomes less, the more the form of the tree's cross section deviates from a circle.

The conversion factor at present in use for *sal* (based on a considerable number of trees) is 0·3119*; the factor calculated from the present data is 0·3155†. The excess in basal area calculated from diameter tape measurements with the use of the former factor is 4 per cent., while with the latter it is nearly 2 per cent.

5. *The time taken* in each measurement was also recorded. It was as under :—

	Callipers minutes	Diameter tape minutes
R.	81	85
S.	76	81

Conclusion.

1. The consistency to be expected from successive measurements with the diameter tape is slightly greater than with callipers, both as regards aggregate basal area, and classification by inch classes.

2. The excess in the basal area with diameter tape measurements over the calliper measurements is 2 per cent. on the present data but 4 per cent. on the pre-existing more comprehensive data. A reduction for this could easily be applied to the tape data.

* Basal area in the case of callipers is calculated from the square of the mean of the two diameters, not from the mean of the squares.

† It should be noted that this factor 0·3155 is independent of the use of the diameter tape as such, since the diameter measurements obtained with it are derived from the actual girth as originally measured, on the assumption made in graduating the tape that the circular relation $g=\pi d$ is valid.

NOTES

By

M. D. CHATURVEDI, *Silviculturist, United Provinces.*

(Abridged.)

Amendments in the existing code should be made as follows:—

(1) A diameter tape should be used in place of callipers.

(2) In the case of trees of abnormal shape at breast height, two cross marks should be made at points equidistant up and down from breast height and the mean of diameter measurements taken as equivalent to the measurement at 4′ 6″.

(3) The minimum width of surround should be 50 feet all round the sample plot and its boundary should be clearly marked. The surround must not be more heavily or differently thinned from the plot itself in the search for sample trees.

(4) The dominant height rather than the mean height of a sample plot should be used in drawing the quality curves (*cf.* page 148). A form is suggested. Dominant height is comparatively free from the influence of stocking and is preferred as the only one possible to determine in the crops in which yield tables are to be applied.

(5) It should not be prescribed that the bottom of the figures should be exactly 6″ above the cross mark.

(6) All sample plots should be remeasured at an interval of 10 years. Interim measurement recording all diameters and the heights of quality indicator trees should be done after 5 years.

(7) Three groups only are required, the middle containing some $\frac{2}{3}$—$\frac{3}{4}$ of the total number of trees and the largest number of sample trees should be taken for this middle group.

(8) The question of the treatment of weeds and shrubs should be settled definitely: it probably does not make any material difference in most cases.

(9) Copies of curves drawn from sample trees should be sent to Provincial Silviculturists.

(10) Field forms for sample trees should be returned to Provincial Silviculturists.

PAPER (*iii*)

Contributed by

G. S. SHIRLEY, *Silviculturist, Burma.*

In connection with the preparation of volume tables, I should like to draw attention to the first recommendation of the sub-committee appointed at the 1922 Conference to deal with statistical matters (*vide* page 90 of the printed proceedings).

The recommendation runs " branch-wood should be measured once for all. The compiler should decide when sufficient data have been collected " so far as I am aware no action has yet been taken to carry out this proposal.

Further discussion seems necessary as, in the case of large trees, branch wood will often include marketable timber and it is very doubtful whether any estimate based on a few trees would produce results of sufficient accuracy.

In this connection it may be noted that, in the latest Form 6 received from Dehra Dun, branch timber is omitted altogether by the insertion of the word " Stem " over the word " timber " in Column 13, while by the division of column 14 " small wood ", into " stem " and " total ", the branch small wood is shown in the column headed " total " by its addition to the stem small wood

Form 5 also omits branch timber although it includes branch small wood.

Form 4, measurements of individual sample trees, is the only form in which branch timber is recorded.

The measuring up of stem and branch small wood down to a diameter of 2″ over bark undoubtedly takes up a great deal of time, while yielding results of little practical importance because the actual outturn of this class of produce is unlikely, except as a matter of luck, to approximate to the measured volume. It would seem desirable therefore to save the time and labour involved in measuring up stem and branch small wood if other satisfactory arrangements can be made.

As regards stem small wood, I gather that there is some difficulty in altering the methods in use because the minimum diameter of stem timber (8″ over bark) is a purely arbitrary limit and, should this be changed, the figures for the previous plots could not be altered to correspond with the new limit unless full details of the total volume of the stem timber and small wood were available. Personally, I cannot see that any such alteration could be made in any case, unless the stem timber limit were reduced to that of the small wood, because there is no other measurement at a fixed diameter either above or below 8″ and the point of distinction could not therefore be traced. As the measurement of stem small wood is not, however, a matter which takes much time I have no wish to press for any alteration in this respect if there are good reasons for maintaining the existing arrangements.

The question of branch small wood is different. The work involved both in the field and in the office is considerable, and I do not consider that the results obtained justify such an expenditure of time and labour. In most cases the produce could only be used as fuel, the marketable outturn of which will seldom bear any resemblance to the solid volume obtained from the statistical measurements. If a record of the volume of branch small wood is necessary, I would suggest that sufficient accuracy would be obtained by fixing an arbitrary figure based on the measurements from a few sample trees in accordance with the sub-committee's recommendation. The figures already collected for teak and *sal* should by now be ample for the production of a graph from which all future calculations can be made.

I wish therefore to propose that action should be taken to prepare graphs of the branch small wood volume of all species for which sufficient data have been collected, and that in future the measurements of branch small wood for these species should be discontinued, the branch small wood volume of future plots being obtained from tables prepared from the graphs. For the sake of uniformity the volumes of branch small wood in the existing plots should be altered to the volumes obtained from these tables. If this proposal is accepted it would be desirable to change the sub-heading of column 14 of Form 6 (Small wood) which has now been divided into " stem " and " total ", from " total " to " branch " so that the actual volumes are distinguished from the estimated volumes.

ITEM 11 (a).

DETERMINATION OF INCREMENT OF TREES WITHOUT RINGS.

A paper was submitted by Mr. M. D. Chaturvedi (United Provinces, *vide infra*).

A short note was also sent in by Mr. Newman, Chief Conservator of Forests, Bombay, (*vide* p. 173). The Central Silviculturist and his Statistical Assistant put the result of their investigations (*vide* p. 173) before a sub-committee (Mr. Simmons, Mr. Chaturvedi and themselves) to which the subject was referred by the Experimental and Statistical Committee. The sub-committee examined the proposals and results obtained with them, and submitted a report which is appended to the resolution below.

The subject matter of the report was debated at some length (*cf.* p. 178) particularly as regards the complications caused by quality class. A resolution was proposed by Mr. M. D. Chaturvedi (United Provinces) and seconded by Mr. Vahid (Central Provinces), and passed by the Conference.

RESOLUTION 11 (*a*).

RESOLVED *that the report of the Sub-Committee be accepted.*

Report of the Sub-Committee.

Two methods which promise to be of value have been evolved and considered : it is recommended that the Central Silviculturist should put these on record with full explanation and examples.

The Central Silviculturist has tested 3 modified forms of the method described by Mr. Chaturvedi (*vide infra*) working in turn with all the dominant trees, with the upper 25 per cent. of the dominant trees, and with the biggest 50 trees per acre. He finds that the best results are given by the last mentioned form, and this is accordingly recommended for use.

With regard to the difficulty as regards Quality Classes, a development of Mr. Chaturvedi's method suggested by Mr. Simmons should be examined by the Central Silviculturist.

PAPER (*i*)

Contributed by

M. D. CHATURVEDI, *Silviculturist, U. P.*

Foreword.

One of the problems which baffles the worker in statistical forestry is the determination of the age of a tree which has no annual rings. All methods dealing with the calculation of increment of forest crops or individual trees are based on the assumption that the age of a tree can be obtained by counting the annual rings at its base. Most tropical species do not, however, form annual rings and a study of their rate of growth is therefore rendered extremely problematic. Many attempts have been made to arrive at a satisfactory solution of this problem but no tangible results have been so far obtained. Text books on forest mensuration either evade the issue altogether or merely indulge in obscure generalities. In the following pages the writer has attempted to indicate a method which, however imperfect, provides at least a basis for discussion. The reader, it is hoped, will appreciate the difficulties involved in dealing with a problem at once so difficult and urgent. Criticism, if it is at all to be helpful, should be constructive and unless an alternative method is forthcoming the procedure outlined in the following pages should be accepted as a last resort, not that it is perfect, but that it is the best we can do for the present.

1. Preliminary Remarks.

1. The obvious method of ascertaining the age of trees which do not form annual rings would be to determine their age from records, compartment-history registers, and other sources of similar nature. Such information, as a rule, is not forthcoming about forests in India where the forest department is of a comparatively recent origin. The rate of growth of such species could also be studied in plantations where the age is known, but considerable time must elapse before any useful data could be collected. Since, however, some sort of information about the rate of growth is indispensable for the management of forests in which species of indeterminate age occur, a method must be devised which would yield the necessary data in a comparatively short period. In course of the compilation of a working plan for the Naini Tal Division, the United Provinces Research Branch was recently faced with the problem of prescribing the management for the *banj* oak (*Quercus incana*) which does not form annual rings and therefore no information about its rate of growth was available. The method outlined below was devised to obtain the ages of *banj* sample plots from which the increment curve was obtained.

2. The only possible mode of attacking this problem seems to be to determine the periodic increment of any dimension of a tree and to plot it against that dimension with reference to the period in which the increment has taken place. It is obvious that the dimension chosen for this purpose should range between zero and the point up to which the curve is to be obtained.

3. The choice of the dimension is governed by a variety of considerations. The volume (v) of a tree is given by the relation

$$v = \frac{\pi d^2}{4} \text{ h.f.} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where, d is the diameter at the breast height and h and f the height and the form factor of a tree respectively. Of these dimensions, the form factor and the volume can be dismissed from our consideration at the outset owing to the difficulties involved in the calculation of their periodic increment.

4. The height, as is often claimed, is the only dimension of a tree which is comparatively free from the disturbing influences of the stocking of a crop, and the treatment to which the crop has been subjected in the past. It would therefore appear to be the most suitable dimension whose periodic increment should be studied for this purpose. Against this may be mentioned that the measurement of the height of standing trees is more susceptible to errors* than that of the diameter at breast height. For an investigation of this nature the periodic increment of the height of trees from the smallest to the largest size will have to be studied. Further complications arise inasmuch as that this particular dimension of a tree becomes fairly constant after a certain age has been reached and the periodic height increment then becomes nearly equal to zero. Thus, if an age (x) height (y) curve is obtained, it becomes impossible to tell the age of a tree if its height happens to fall on that part of the curve which is parallel to the axis of x (representing age). It only remains to add that for crops (sample plots) the study of the periodic increment of the dominant height presents the same difficulties as in the case of single trees quite apart from the errors involved in the calculation of the dominant height of a crop. Then again, the usual data supplied by a sample plot are insufficient for the purposes of a height curve since the periodic increment of the dominant height of a plot yields only a single point for the curve. While it is true that the periodic increment of the mean diameter of a plot also yields only a single point, the diameter increment of every single tree in the plot is usually available, which is not the case if heights are taken into consideration.

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* The errors involved are:—

(1) The error of the instrument.
(2) The error due to the non-verticality of the tree.

The latter is quite serious involving, as it does, an error of about +8 and −9 per cent. if the tree deviates even by 5 degrees from the vertical towards or away from the observer respectively. (1).

5. The chief objection against the choice of the diameter for purposes of this investigation consists in its being very susceptible to the influences of the density of the crop in which a tree occurs. These influences can, however, be considerably minimised, if not altogether eliminated; by considering diameters of trees growing in crops of normal stocking. Such crops are, as a rule, rare in nature, but control over the influence of the degree of stocking on the diameter and its increment can be exercised by starting with normally thinned sample plots and omitting from consideration the diameter increment put on by trees in course of the first period of 5 years. Normal sample plots, laid out in crops which were previously unthinned or thinned irregularly, show a periodic increment of diameter well above the average owing to the stimulus caused by a sudden opening up of the canopy at the time of thinnings. During the second period when the trees have settled down to their altered conditions the increment may be taken for all intents and purposes as normal.

6. A hypothesis based on a close study of several evenaged sample plots of various species may be enunciated here as it will throw light on the method of eliminating further the influence of the density of a crop on the diameters of its trees. It has been observed that in a sample plot of a given age, trees show considerable variations both in diameter and height. Thus, for example a *chir* (*Pinus longifolia*) plot in the Baldhoti plantation (Almora, United Provinces) of a known age of 46 years showed diameters (b. h.) ranging from 6 to 17 inches and heights from 46 to 78 feet. We have therefore the curious phenomenon of two trees of the same age growing side by side with diameters varying from 6 to 17 inches. The periodic increment of their diameters has been obviously very erratic for the last 46 years, and any method based on these trees is likely to yield misleading results. Various factors like heredity, variations in soil and environment are responsible for inducing such a state of affairs in a sample plot containing trees of the same age. The chief among them is, however, the factor of dominance (environment). A seedling suppressed from the early stages of its development could not possibly hope to attain the same dimensions as its rival with plenty of growing space. The density of stocking, it will be seen, has very considerable influence on the development of diameter. It may also be added that height is not entirely independent of stocking either, since a range of 46 to 78 feet among trees of the same age is not inconsiderable.

7. A graphic representation of the distribution of trees over various diameter classes in a plot reveals the fact that trees with such extreme diameters are few and far between. The frequency of diameters in an evenaged sample plot follows the probability curve*. It has been observed that a large number of trees (from $\frac{3}{8}$rd to $\frac{3}{4}$th) in a stand group themselves around a particular diameter. This diameter, which is most frequent or which is most in fashion (*la mode*) is known as the mode (2) as distinguished from the mean diameter of a plot. With increasing variation from the mode diameter, the number of trees falls continuously on either side (positive or negative). Nature, it would appear, is continually striving to make all trees to one pattern (mode) and succeeds in a very large number of cases while the number of failures is very few. Thus, in a stand the number of the biggest and the smallest trees is exceedingly small compared with the trees which crowd around the mode diameter.

8. If the principles enunciated above are conceded then the whole problem is exceedingly simplified. The abnormal factors of growth like dominance,

* The equation of the probability curve, known as Gauss' law of errors is:—

$$y = \frac{h}{\sqrt{\pi}} \cdot e^{-h^2 x^2} \cdot dx.$$

where y is the frequency or rather the probability of a variation, dx, from the most probable value which in this case may be taken as the mode diameter of trees in a stand. As dx increases, the number of trees y decreases. $\frac{h}{\sqrt{\pi}}$ represents the maximum probability or the number of trees whose diameters do not vary at all from the mode, or in other words, it represents its frequency. The magnitude h represents the modulus of precision. The physical signification of this magnitude is that the greater the value of h, the less will be the deviation of individual trees from the mode diameter, and hence h varies with the density of a stand—the variation being less in closely grown well thinned woods. (1).

variations in soil, undulations in ground, and specific variations express themselves in abnormal trees. Trees round about the mode diameter represent the average results of the factors of growth. Therefore in an investigation of the periodic increment of diameters, only average trees should be considered and all abnormal trees must be carefully omitted. For the same reason all suppressed, dead, dying and injured trees should be ruled out of consideration since they do not result from average conditions of growth. It may now be stated that the average dominant diameters around the mode diameter in a plot are as independent of stocking as dominant heights. For purposes of this study, therefore, the diameter is as suitable a dimension as the height and should be preferred since it is easier to measure and less susceptible to errors.

9. Attention may now be drawn to the question whether the investigation of the periodic increment of diameters should be limited to single trees or crops (mean trees of sample plots) For obvious reasons, it would be essential that sample plots or single trees whose increment is to be studied for the purpose must be of the same quality. Since, however, there is no means of determining the quality of sample plots without knowing their mean age, it will be necessary to lay out a very large number of plots, in the same locality and with identical growth conditions whose quality may be assumed invariable for all practical purposes. Thus for every single locality, it would be essential to lay out a complete series of sample plots whose mean diameters would range between zero and the diameter to which the curve is to be constructed. Apart altogether from the labour involved in duplicating this series in every type of locality, the probability of obtaining a complete series of plots in a given locality of the same quality is extremely remote. Practical considerations, therefore, limit this investigation to single trees rather than crops, *i e* , mean trees of sample plots.

2. The Method.

10. The *modus operandi* to be followed may now be briefly described here. Lay out a complete series of sample plots in all types of localities in which the given species, for which a yield table is to be compiled, occurs. The only departure from the standard procedure is that where for a species with rings only one sample plot would suffice, 3 to 4 plots of identical quality and varying age would be needed for a species without rings. Identical quality is best secured by laying out 3 or 4 plots of different ages in the same geographical locality with identical growth conditions. In such a locality these plots may be assumed, for all practical purposes, of one and the same quality. A single plot which could not be correlated with other plots of different ages and of identical quality would be useless for the application of this method. It is enough that a set of sample plots in a given locality should be of one and the same quality. As to what is that quality is immaterial. We had thus for the *banj* oak (*Quercus incana*) a species which does not form annual rings, the following sample plots.

Table 1.

Locality.	No. of sample plots	Remarks.
1. Bhatronj	4	This series is not yet complete.
2. Bhowali	6: 2 recent.	
3. Chakrata Cantonments	4	
4. Chaubattia	7	
5. Kilberry	2	
6. Lansdowne	3	
7. Majkhali	6	

11. The mode tree, as has been appointed out above, represents the average result of the factors of growth in a given quality of locality. To investigate the rate of growth of the mode tree the periodic increment of dominant trees round about the mode diameter should be considered in plots of unvarying quality. For this purpose dominant trees of the same or nearly (by

0·5 inches) the same diameter should be grouped together and the difference between the arithmetical average diameters of the same group at the initial and the final measurement may be considered for all practical purposes, as representing its periodic increment. Strictly speaking the average diameter of a group should be the square root of the mean of the squares of the diameters included in that group, but for all practical purposes, the linear average of diameters grouped in half an inch class could be taken instead without any perceptible error. This grouping, apart from reducing the large number of points which would otherwise have to be plotted and avoiding the consequent confusion arising therefrom, secures the indispensable condition that the periodic increment should be based on single trees growing under varying environments (excluding the extremes).

12. For the determination of the ages of sample plots of identical quality, an age-diameter curve should be constructed *separately* for each quality of locality. The curve is obtained by plotting the periodic diameter increment against the diameter with reference to the period. The age of a sample plot can then be read off the curve against its mode diameter. It may be pointed out here that the mean diameter of a sample plot, including as it does the extreme diameters as well, is an artificial quantity and is useless for our purpose. The arithmetic mean gives no idea of the real average of the trees which are most frequent. For an investigation of this nature what is needed is the diameter which is the fashion (mode). The determination of the mode diameter is, however, attended with serious difficulties. One of the methods usually recommended in text books consists in fitting an ideal frequency curve of a given equation to the curve actually obtained by plotting the number of trees against diameters. The value of the variable corresponding to the maximum of the fitted curve gives the mode. By far the simplest method, however, is to determine the value of the mode from the following formula,

$$\text{Mode} = \text{Mean}^{*} - 3\,(\text{Mean} - \text{Median}\dagger)$$

For moderately a symmetrical frequency curves this relation gives a close approximation of the value of the mode (2).

13. To illustrate the procedure described above the following example has been worked out for *chir*. Three sample plots in the Baldhoti plantation at Almora were chosen for this purpose. The choice of the species and the locality has been deliberate since our knowledge of the exact age of these sample plots from records would enable us to check the accuracy of the method adopted. The following table gives the necessary information about the sample plots under consideration.

TABLE 2.

No.	Diameter (Breast height).			Mean height.	Locality.		Year of laying out.	No. of trees per acre.	Age from records.
	Minimum	Maximum.	Average.		Elevation.	Soil.			
	Inches	Inches.	Inches	Feet.	Feet.				years.
37	2	7	4·4	25	5,000	Loose sandy loam. Fairly deep. Slightly humose	May 1916 .	802	(1916) 17
51	4	14	8·3	47	5,000	Ditto .	May 1921 .	439	(1921) 29
53	6	17	10·7	65	5,000	Ditto .	May 1921 .	270	(1921) 46

All these plots are situated in the same type of locality on a southern aspect and with fairly identical conditions of growth. The elevation, the soil and other factors of locality being fairly constant, it has been assumed

* The mean is the simple arithmetic mean and not the square root of the mean of the squares of diameters.

† The median is that diameter which equally divides the number of trees contained in a sample plot. Thus, half the trees are contained in diameter classes above and the other half below it.

that these plots represent a single type of locality of unvarying quality. It is enough to know that these plots are of the same quality. The actual determination of the quality is irrelevant to the present issue.

14. Assuming now that the diameter growth of average dominant trees in these normally thinned sample plots is the same, or that the sample plot No. 37 would grow into sample plots 51 and 53 at the ages of these plots, we can easily determine the ages of these plots. Omitting the extreme trees we have the following range of diameters to consider.

TABLE 3.

Plot No	Actual Range of Diameters		Considered Range of Diameters.	
	Minimum	Maximum	Minimum	Maximum.
	Inches.	Inches.	Inches.	Inches.
37	2	7	2·5	6
51	4	14	6	12
53 . . .	6	17	9	14

15. Grouping these diameters which occur between the limits given above (Table 3) in half inch classes, the periodic increment of the arithmetic mean average of each group during 5 years is given below.

TABLE 4.

	D. b. h (Inches)											
Initial . .	2·7	3·7	4·4	4·8	5·3	5·7	6·2	6·7	7·3	7·7	8·2	8·8	9·3
After 5 years .	3·8	4·4	5·1	5·4	6·1	7·0	7·3	7·7	8·3	8·7	9·1	9·7	10·1
Initial . .	9·8	10·3	10·9	11·3	11·7	12·2	13·0	13·1	13·6				
After 5 years .	10·7	11·2	11·9	12·4	12·9	13·3	14·0	14·5	15·1				

The rate of growth of the mode tree of this locality can now be easily ascertained from the periodic increments given in the table above. Thus, on an average the mode tree of 5·7 inches in diameter would grow into 7·0 inches in 5 years. This increment is based on a group of trees* growing under varying environments as dominant or sub-dominant in the same or different sample plots. All dead, dying, suppressed and dominated trees have been excluded. The periodic increment of the mean diameter (5·7 inches) of the group represents its true average growth. The overlapping of limiting diameters of various sample plots is essential only to obtain continuous set of increment figures for all diameters. In studying the rate of growth of the mode tree, it has been assumed that it has grown in the same proportion right through its life as the mean diameters of individual groups have in five years (*vide* Table 4). Thus, the increment of the mode tree of 2·7 inches in diameter has been supposed to be equivalent to that of the

*The group actually contained the following trees:—

Diameter class 5·6—6·0 (inches.)	Initial D. b. h.	After 5 years D. b. h.
	5·6	6·4
	5·8	7·2
	5·6	6·5
	5·8	7·2
	5·8	7·1
	5·9	7·4
TOTAL .	34·5	41·8
MEAN .	5·7	7·0

group of trees of mean diameter 2·7 inches. This group of trees, it will be seen (*vide* Table 3) is confined to sample plot No. 37, in which every tree is of the same age. Since, this group represents about the lowest diameters in the plot, it is obvious that trees included in it have not grown under optimum conditions in the past. A thinning carried out at the laying out of the sample plot secured normal conditions of growth for these trees. The increment put on by them subsequently, with the exception of the first period when it is likely to be abnormal, may be taken as normal for a diameter of 2·7 inches, which represents the mean of the whole group, irrespective of past treatment. The assumption being that these trees, given normal sample plot conditions in the past would have grown as they have, after such conditions have been restored to them at the time of laying out the sample plot.

16. We may now proceed to construct the age diameter curve for the mode tree which obtains under sample plot conditions in this locality. We know that a diameter of 2·7 inches becomes 3·8 inches in 5 years. In order to build up the curve it is necessary to ascertain the increment of diameter 3·8 inches in the next 5 years. Working on linear proportions we could obtain this information from Table 4. Since a diameter of 3·7 inches becomes 4·4 inches in 5 years (*vide* Table 4), a diameter of 3·8 inches in 5 years (*vide* Table 4) could be supposed to grow in the same proportion. Assuming now the age of the average tree of the diameter 2·7 inches as a years, we can determine, as above, its increment in periods of 5 years. We have thus:—

TABLE 5.

Age years.	D. b. h. Inches	Age years.	D. b. h. Inches.
a	2·7	$a+30$	8·4
	1·1	$a+35$	9·3
$a+5$	3·8		0·9
	0·7	$a+40$	10·4
$a+10$	4·5		0·9
	0·7	$a+45$	11·3
$a+15$	5·2		1·1
	1·1	$a+50$	12·4
$a+20$	6·3		1·1
	1·1	$a+55$	13·5
$a+25$	7·4		1·1
	1·0	$a+60$	14·6

17. These co-ordinates may be plotted now on a graph paper (Curve opposite). The value of a could be worked out graphically. The point where the curve cuts the y-axis (representing age) is the point where the diameter breast height (4 ft. 6 inches) of the average tree is zero. It should be remembered that the maximum height of a plant is 4 ft. 6 inches when its d.b.h. is zero. The age at this point would therefore be the age of an average *chir* sapling 4 ft. 6 inches in height. Assuming this age to be 5 years the x-axis can be translated up or down as necessary to give the required value of y at the point x=0. The value of a can now be read against the y-axis direct. In the construction of the curve it should be remembered that the rate of growth of diameters is quite rapid during the early stages of the life of a tree. This is followed by a phase of comparatively slow growth.

NOTE

By

H. L. NEWMAN, *Chief Conservator of Forests, Bombay.*

In the matter of fixing the rotation, determination of increment (principally of girth) is the most important point. A perusal of the Working Plans of the Presidency shows that:—

(*i*) The mixed deciduous forests containing teak, are managed principally for their teak. In such cases the exploitable age of the whole mixed crop is kept the same as that of the teak which shows distinct annual rings, and the exploitable age of which consistent with objects of management can thus be easily ascertained.

(*ii*) In *injaili* forests in which the ring-forming species constitute a fair proportion of the crop, the girth increment of such species is ascertained and rotation of the whole crop fixed on that basis.

(*iii*) In *injaili* forests in which the ring-less species predominate, the exploitable age is empirically fixed unless successive cuttings for a long period say 30 or 40 years are available in which case the girth increment can be easily ascertained (*vide* Working Plans for Gokak and Gujnal Ranges, by Mr. E M. Hodgson).

2. In the case of species without rings, the only way of determining increment is—

(*i*) either to take measurements in crops of known ages.

(*ii*) or to keep a few sample plots under observation for the required number of years.

The ringless species of the Bombay Presidency, however, are not of sufficient importance nor are likely to be in near future to justify such sample plots being undertaken at present.

NOTE ON PAPER (*i*) ABOVE

By

H. G. CHAMPION, *Silviculturist, Forest Research Institute.*

Plots selected for test.—It might have been preferable to have taken natural regeneration plots rather than plantations since the method is to be applied mainly to natural regeneration. The Almora plantations are also not very suitable as early growth is beyond question abnormally good for the locality quality. Further, if these plots be compared with a number of others, No. 37 seems to be abnormal in any case, and the important initial part of the curve depends on No. 37.

Elimination of trees from calculation.—This has been done on an entirely personal basis and so is highly unsatisfactory. Each tree appears to have been considered as regards the number of trees in the class including it, and as regards its increment, and arbitrary rejections made. Incidentally this makes it almost impossible to check the calculations printed. Elimination of the bigger trees as abnormal is unacceptable since it is precisely these trees which will form the future crop.

Calculations.—There appear to be misprints in Table 6 as the values read from the curve are 20, 33 and 49 respectively not 28, 33 and 46. The mathematical processes utilised are open to all the usual objections of combining single tree (or diameter class) figures to crop average values, whether